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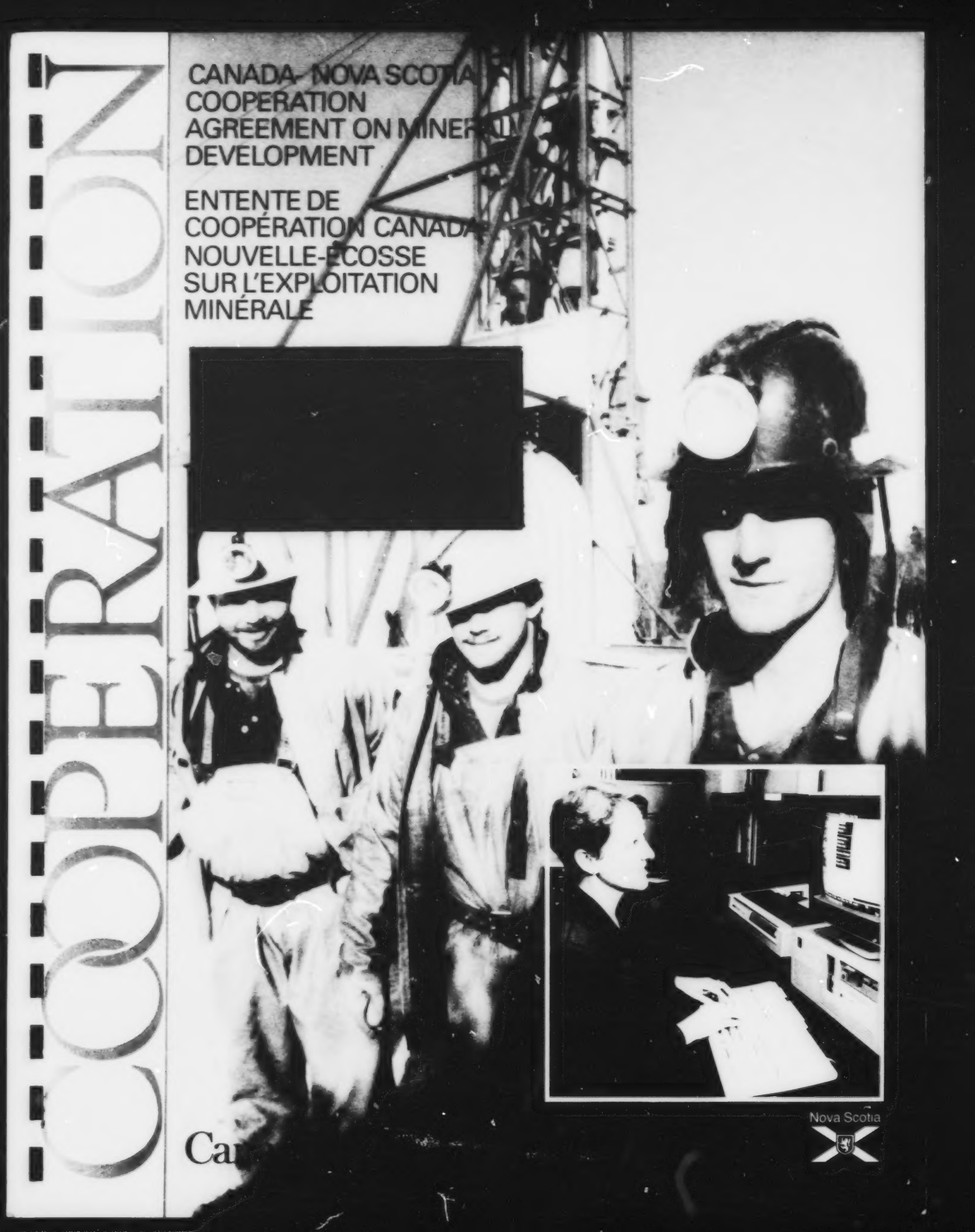

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VOL II of VII

A STUDY ON THE CONTROL OF GROUNDWATER HAZARD AT GAYS RIVER MINE

VOLUME II

PHASE I REPORT

GAYS RIVER MINE DEWATERING AND WATER INFLOW PREVENTION

By: G. M. Meyer

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GAYS RIVER MINE DEWATERING AND WATER INFLOW PREVENTION NOVA SCOTIA, CANADA

By

WESTERN MINING CORPORATION LIMITED
EXPLORATION DIVISION - MINERALS (AUSTRALASIA)

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DALY ST, PERTH
FEBRUARY 1991

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1. INTRODUCTION

The Gays River Mine is located in the Milford area of Nova Scotia, approximately 70km north-east of Halifax (Figure 1).

This report presents a total overview of the hydrogeological regime at the minesite and uses this overview to make recommendations to solve mining problems currently being experienced by groundwater inflows. The report follows a 3 week period at the minesite when all reports and hydraulic data were collated and analysed and water inflows inspected. The study was prompted by the urgent need to control mine water levels which were severely reducing both mine tonnage and grade production.

The Gays River Pb-Zn deposit mineralization occurs as a disseminated form within a carbonate reef and as a high grade, massive form along the sloping flank of the reef. The host carbonate of Mississippian age is unconformably overlain by a weathered evaporite sequence. Pre-glacial erosion along the contact between the carbonate and evaporites resulted in a wedge shaped trench filled with a heterogeneous mixture of clay, sand silt and gypsum rubble. Overlying the bedrock sequence is up to 40m of glacial till and glacial-fluvial sands and gravels (Figure 2).

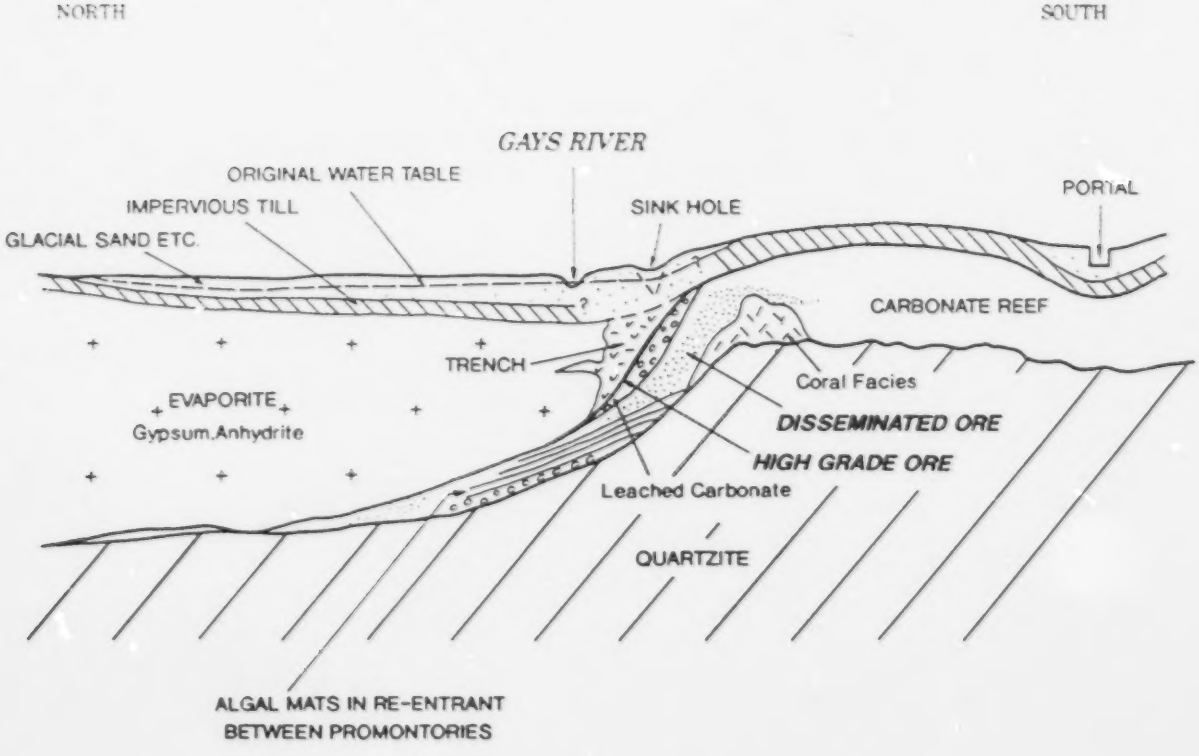
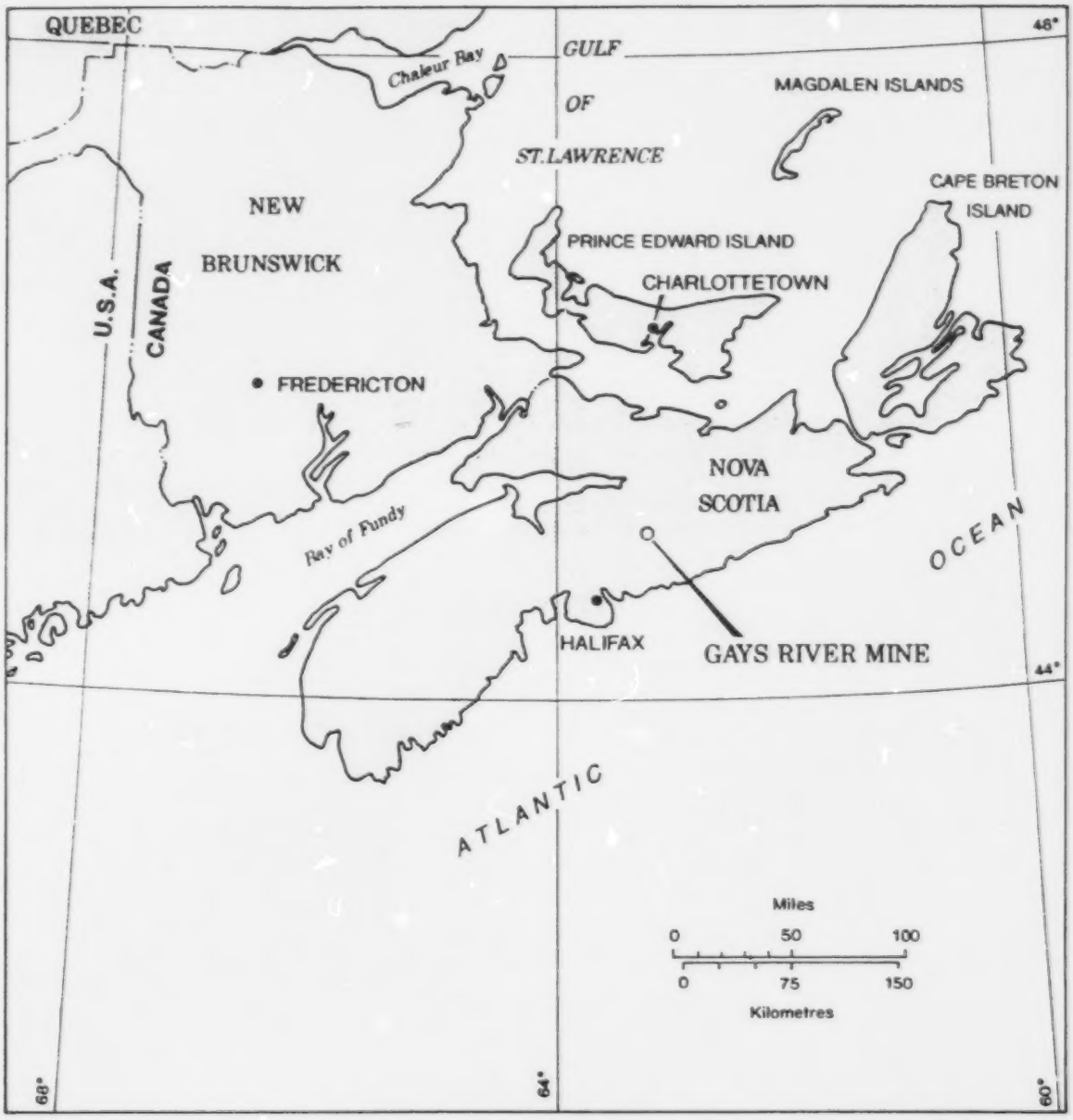


FIGURE 2 – **TYPICAL CROSS SECTION**

(after Mckee,D.M.,etal,1982)

PLAN No. 10 010–03



WESTERN MINING CORPORATION LIMITED - EXPLORATION DIVISION			
Map Ref.		GAYS RIVER MINE DEWATERING AND INFLOW PREVENTION STUDY LOCATION PLAN	Scale
Date	FEBRUARY 1991		Figure No. 1
Author	G. MEYER		Plan No. 10 010-01
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1.1 Hydrogeological Setting

The hydrogeology of the deposit has been described several times in various consultants' and mine staff reports, but notable are reports by D M McKee and P J Hannon which summarised the hydrological environment after the mine was closed down in 1982 and a recent report by Jacques, Whitford and Associates Limited which summarised the hydrogeology and hydrology of the mine area as part of the Gays River Overburden Stability Investigation. Other key reports prepared by various consultants were :

Dames and Moore, Consulting Engineers, 1974a and 1974b, 1976, 1980a and 1980b.

Leggette, Brashears and Graham, Inc., 1982a and 1982b, 1983 and 1989.

Martec Ltd., 1981, 1988, 1989a, 1989b, 1989c, 1990 and 1991a and 1991b.

From early work on the project it was realised that most water was contained in sands and gravels making up parts of the glacial overburden sediments and in karstic gypsum cavities located adjacent to the trench. The Gays River mine area can therefore be considered as having 2 principle aquifers. The Overburden Aquifer comprised of the highly permeable glacial and fluvial gravels and coarse sands and less permeable fine sands and silts; and the Bedrock Aquifer comprised of the highly permeable interconnected karstic gypsum cavities as well as hydraulically connected, but less permeable fractured carbonates and quartzites. Both aquifers are hydraulically connected where permeable overburden sediments are physically in contact with permeable bedrock cavities or fractures.

1.1.1 Bedrock Aquifer

The Bedrock Aquifer comprises quartzites of the Meguma Group, carbonates of the Windsor Group and evaporites of the Gays River Formation. The quartzite is generally impervious and dry with the exception of rare fracture zones while the overlying carbonate is also generally impermeable except where highly jointed and near the contact with the trench.

The main body of the evaporites is of poor or low yield as evident from an inspection of a nearby gypsum quarry. The contact zone with the trench has however been shown to be highly permeable due to numerous sand filled karstic cavities. The sand is probably piped from the Overburden Aquifer as surface sinkholes form after removal of sand from underground drainholes.

The geohydrology of the Bedrock Aquifer is better understood than the Overburden Aquifer due to the drilling and monitoring of deep water observation and production bores. These holes are shown on Plan 10010-04 and are summarised in Table 1. The deep holes were designed to intersect permeable Bedrock Aquifer, in particular karstic gypsum near the base of the trench. Holes DW3, ETW1 and ETW2 were successful at intersecting major cavities at 418RL, 434RL and 424RL respectively (Table 2). Hole OW1 intersected high yielding, gypsum cavities near the base of sandy Overburden Aquifer at shallow depth (481RL) and had to be abandoned due to drilling difficulties imposed by the cavities. Hole ETW3 intersected a good supply estimated to be between 300 and 500USgpm in what are thought to be carbonates (depth unknown). Other holes intersected low yielding solid gypsum, carbonates and quartzites.

TABLE 1

GROUNDWATER DRILLING SUMMARY

PROJECT GAYS RIVER

HOLE#	HOLE STATUS	EOH	COMPL. DATE	NORTHING	EASTING	COLLAR RL	SWL	SWL DATE	AQUIFER NAME	AQ.TOP	AQ.BASE	FLOW USgm	EC@25C umhos/cm
DW-1	OB	128.30	07-01-1980	7246.00	8693.00	518.47			CARBONATE			LOW	
DW-2	OB	133.00	14-01-1980	7294.00	8891.00	525.29			EVAP-CAVIT	76.00	82.00	N/A	
DW-3	OB	133.20		6887.00	8540.00	530.52	23.87	15-03-1980	EVAP-CAVIT	83.00	84.00	>700	
									EVAP/CARB	112.00	122.00		
ETW-1	OB	119.80		6850.00	8485.00	535.22			EVAP-CAVIT	85.30	115.80		
ETW-2	OB	112.20		6745.00	8175.00	542.81			EVAP-CAVIT	64.00	79.30		
									EVAP-CAVIT	100.60	112.20		
ETW-3	OB	91.40		6610.00	7920.00	546.67			?CARBONATE			400	
ETW-4	OB	88.40		7610.00	9425.00	521.30							
H-1	ABAN	73.00	22-07-1974						GLACIAL SN	9.00	12.00	5	
									CARBONATE	15.00	31.00	15	1000
									QUARTZITE	41.00	73.00	20	1250
H-2	ABAN	41.80	08-08-1974				5.00	27-09-1974	CARBONATE	30.00	41.00		
H-3	OB	106.70		6251.00	7667.00	555.84	43.53	15-03-1980	GLACIAL SN	50.00	60.00	100	
									EVAP-CAVIT	65.00	106.00		2100
H-4	OB	96.90	22-08-1974	6718.00	8043.00	550.05	41.66	15-03-1980	GLACIAL SN	49.00	56.00	5	
									CARBONATE	64.00	90.00	55	2200
H-5	OB	18.90	29-08-1974	7370.00	9291.00	515.27	12.53	14-03-1980	OVERBURDEN	6.70			
H-6	ABAN	76.20	05-09-1974				5.20	27-09-1974	GLACIAL SN	5.50	10.00	100	400
									CARBONATE	18.00	53.00	30	1200
H-7	OB	54.30	26-09-1974	7469.00	9344.00	519.35	40.32	15-03-1980	GLACIAL SN	5.00	42.00	70	320
									CARBONATE	44.00	54.00		
M. W. #1	OB	4.15		4957.20	8083.90	520.50	0.90	04-10-1989					
M. W. #2	OB	4.01		4916.66	8075.44	520.32	0.23	04-10-1989					
OW-1	ABAN	45.70		7214.00	8494.00	520.29	10.23	15-03-1980	EVAP-SND-C	39.60	45.70	150	
OW-1A	OB	103.60		7181.00	8473.00	518.21	13.36	15-03-1980	EVAP/CARB	96.00	102.00		
OW-2	OB	86.30		7270.00	8840.00	522.36	40.23	15-03-1980	EVAP-SND	71.00	77.00	35	
OW-3	OB	52.40		7358.00	9071.00	519.44	28.40	15-03-1980	EVAPORITES	44.00	47.00		
OW-6	OB	31.10		6704.00	8337.00	544.98	20.10	15-03-1980	UNKNOWN	26.00	30.00		
OW-7A	ABAN	90.50							EVAP/CARB	82.90	89.00	30	
WCI-GR-P1	OB	21.00		5142.46	9118.76	524.63	5.90	11-10-1989					
WCI-GR-P2	OB	18.60		4805.05	8544.48	525.10	4.25	04-10-1989					
WCI-GR-P4	OB	7.50		6177.05	8698.88	533.21	5.71	18-10-1989					
WCI-GR-P5	OB	18.00		6656.24	8773.94	532.16							
WCI-GR-P6	OB	12.10		7355.41	8614.88	515.79	4.36	22-09-1989					

TABLE 2

MAIN BEDROCK AQUIFER ELEVATIONS
(Measured from Vertical Hydrogeological Exploration Holes)

Area	Hole No	Aquifer	Comments
Western	H4	486 - 460	carbonate aquifer
	ETW2	478 - 464	?main evaporite cavities
		434 - 419	evaporite cavities
	ETW3	?	?carbonate aquifer
Central	DW3	447.5 - 448.5	minor evaporite cavity
		418 - 408	major evaporite cavities
	ETW1	450 - 434	minor evaporite cavities
		434 - 419	major evaporite cavities
	OW1	481 - <474	evaporite cavities
	OW1A	422 - 416	major evaporite cavities
Eastern	DW2	449 - 443	evaporite cavities
	OW2	451 - 445	minor evaporite cavities
	OW3	475 - 472	evaporite cavities

The quantity of groundwater flow through the trench is poorly understood. At places it is composed of over-consolidated silts and clays and is essentially impermeable. At other places, particularly in the deeper parts, it is composed of gravels and is therefore suspected to be permeable and to be part of the Bedrock Aquifer (pers. comm. Chris Cavanagh, Mines Department Geologist, formerly employed at Gays River mine site).

1.1.2 Overburden Aquifer

The overburden sediments comprise a thick mantle of relatively impermeable clayey glacial till with some localised sand and gravel deposits. The clayey glacial till is cut by thick glacial-fluvial deposits of sand, silty sand, and gravel which in places are in contact with bedrock. Two early hydrogeological investigation holes, H3 and H6 intersected moderately high flows (100USgpm) from glacial-fluvial sands and gravels (Table 1).

The present river is depositing silt and fine sandy silt alluvium in the valley of the Gays River and its flood plain. The alluvium at the base of the river is impermeable as documented by recent tracer tests, but the flood plain could be permeable as demonstrated by the contribution of water to mine discharge following flood events. The alluvium is hydraulically connected to, and considered part of the Overburden Aquifer.

1.2 Definition of Problem

Mining problems due to groundwater conditions have been a concern since the Gays River Mine was opened by Imperial Oil Limited (IOL) in 1979. From 1979 to 1981 IOL removed 554 000 tonnes of ore and 272 000 tonnes of waste rock before operations were abandoned due partly to a "severe hydrological problem" (McKee et al, 1982).

Prior to mining, IOL assumed that only overburden sediments near the decline portal would need dewatering as bedrock would act as a natural barrier to prevent water moving from the

Prior to mining, IOL assumed that only overburden sediments near the decline portal would need dewatering as bedrock would act as a natural barrier to prevent water moving from the overburden to deep mine workings. They anticipated high water flows in karstic gypsum and trench sediments, but planned to keep a 6m "safeback" between mine openings and the overburden or trench contact. In addition, 6m of solid corable evaporites was required immediately over the ore zone for mineable reserves laying immediately under evaporites. Mine dewatering was expected to be achieved by conventional pumping and occasional grouting. The total mine discharge was predicted to be 3000USgpm.

Development of the mine was soon impeded without advance dewatering. Development cycles were disrupted, headings were flooded necessitating alternate pumping down and mucking out. One large inflow of 1500USgpm at the 119G area was accompanied by 1 to 2 tonnes of sand per hour and was only controlled by pouring large reinforced concrete bulkheads. In another incident 60m of decline was lost when water at 100psi pressure was intersected.

The solids contained in the water buried pumps, cut impellers and mechanically enlarged the inflow channels. The inflow of solids eventually led to the ground surface collapsing forming sinkholes which needed filling with waste and capping with clay to prevent direct inflow from the Gays River.

IOL attempted several dewatering techniques including:

a) drilling dewatering drainholes from underground to drain overburden sediments. These were drilled in late 1979, but apparently resulted in only partial dewatering of the overburden.

b) The next stage was drilling of surface dewatering holes designed to intersect sand filled cavity sections in the gypsum near the trench. Three production bores (DW1 to 3) and 6 observation bores (OW1, 1a, 2, 3, 6 and 7a) were drilled in 1980, but only one production bore (DW3) was successful. The other production bores and all but one of the observation bores had low flow rates as they were unsuccessful in locating karstic gypsum cavities and therefore in locating the most permeable rock units (Dames and Moore, 1980a). Production bore DW3 was pumped at between 500 and 700USgpm and apparently obtained a significant improvement in mine water levels.

   Leggette et al, in 1982 followed up Dames and Moores' work by drilling 4 more surface bores (ETW1 to 4). The first hole was drilled near DW3 and intersected similar high flow rates, but experienced drilling difficulties, the second hole had low flow rates, but the third hole was never followed up due to a decision to try underground drainholes. The fourth set did not intersect significant cavities. All sites were completed as observation bores.

c) Apart from using production bore DW3, IOL abandoned the concept of drilling vertical dewatering bores from the surface in favour of underground drainholes. Their high cost, drilling difficulties and uncertainty of intersecting the desired aquifer made drilling short drainholes from underground positions more favourable. Particularly successful underground drainholes were drilled in the 118 area and continue to be the main source of drainage in the mine. Their only problem is they introduce large volumes of sediment that drain from the cavernous gypsum. This leads to mechanical pumping problems, and creation of surface sinkholes which needed filling.

Prior to development of drainholes in the 118 area it was decided to proceed with mine development in the 119 area. Although the area was still under the saturated Overburden Aquifer it was thought to be protected by 6m or more of solid evaporites. Careful test holing and grouting in the 119G area still did not prevent a massive inflow of 1500USgpm following blasting. IOL then considered that mine development could not proceed without complete depressurisation of water bearing aquifers and the production operations were later suspended to determine the feasibility of controlling water inflows (McKee et al, 1982).

Other groundwater problems reported by IOL were lack of capitalisation caused by the assumption that only 3 000USgpm would be produced from the mine. There is no evidence to support this value which was thought to have almost been a good guess.

Westminer (Canada) began dewatering the mine in April 1989 and quickly lowered water levels in the Bedrock Aquifer to IOLs previous levels by August of that same year. The early success was due to the satisfactory operation of the 118 drainholes and also partly due to use of dewatering bore DW3. This early success was however short lived as the 118 drainholes became blocked in late November 1989, causing water levels to rise 40m in only 2 days and effectively shutting the mine down for 2 months (Figures 3 and 4). Removal of the blockage and installation of additional drainholes at 118 brought the water level back to previous levels, but drainhole blockages again caused water levels to rise disrupting mining operations in February/March 1990, June/July 1990 and again in January 1991.

As shown on Figure 3, river flooding and high rainfall also caused mine water level rises in June 1990, November/December 1990 and January 1991. All these incidents have caused lost mine production due to flooded headings. As well as causing mine water levels to rise, mine discharge rates also increased by 500-1500 USgpm during each river flood event (Figure 4).

In view of these mining problems the aim of this report was therefore to establish a practical set of recommendations. These recommendations were considered under 4 headings:

i) Recommendations to increase the rate of drainage from the mine to prevent water level rises caused by drainholes blocking or excess water entering the mine during high rainfall and river flood events.

ii) Recommendations to stop sand draining from cavities and thereby reduce surface sinkhole activity,

iii) Recommendations to prevent or reduce water flowing from the Overburden Aquifer to the Bedrock Aquifer, and

iv) Recommended adjustments to the current hydrological monitoring programme.

2. DEFINITION OF THE GROUNDWATER FLOW REGIME

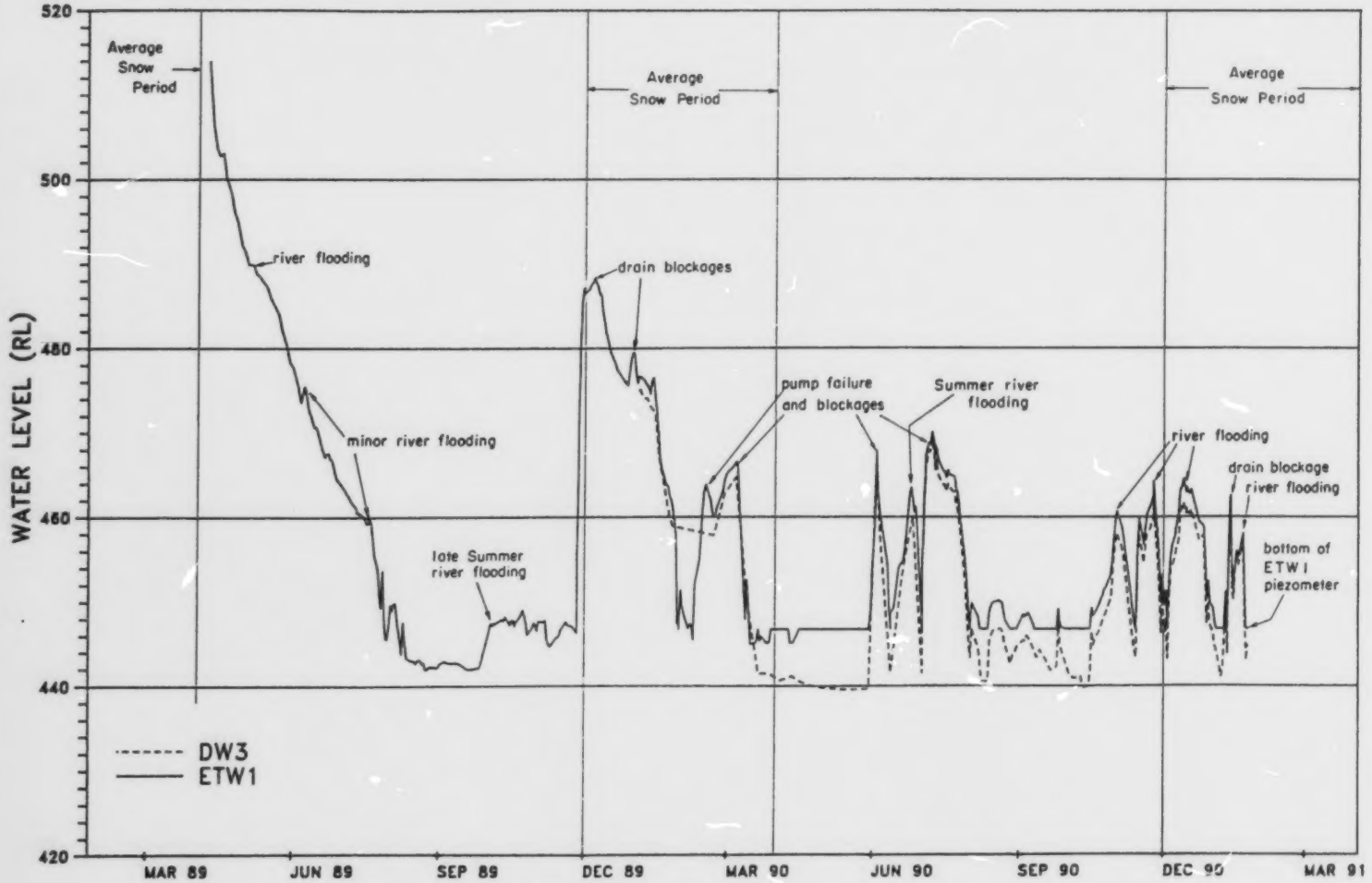
2.1 Summary

The groundwater flow regime at the Gays River Mine is summarised in Figure 5.

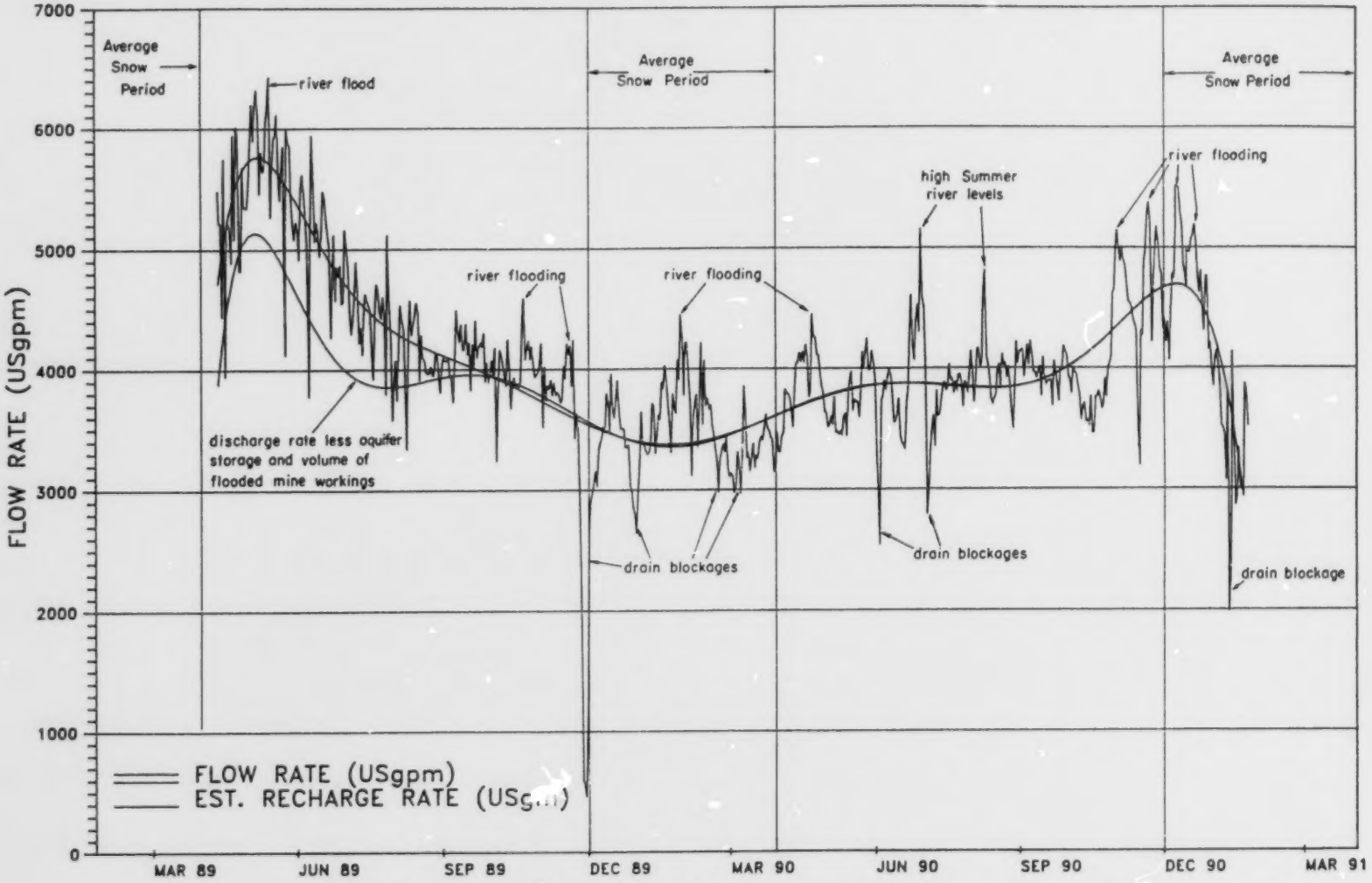
Precipitation collecting on the surface catchment area infiltrates into the soil horizon and into areas of outcropping, permeable glacial sediments and to a lesser extent, older fractured or cavernous bedrock. Some of this water infiltrates further down through the unsaturated zone to the Overburden Aquifer and some is transpired by vegetation, particularly in the spring and summer months. When the soil moisture capacity is exceeded, excess precipitation becomes surface run-off which collects in the Gays River and South Gays River. A small amount of water would be lost by evaporation, particularly in Summer months.

During Winter months, ground freeze reduces the infiltration rate and some water is held in temporary storage as ice and snow cover. This has the effect of lowering the average mine discharge rate from 4000 to 3500USgpm.

Central to the groundwater flow regime is the Overburden Aquifer which receives water from infiltration as described above, from melting ice and snow and from river flood events. Originally it was considered that a significant proportion of water was entering the Overburden Aquifer from the base of the Gays River (base-flow), but a recent dye tracer study by Martec

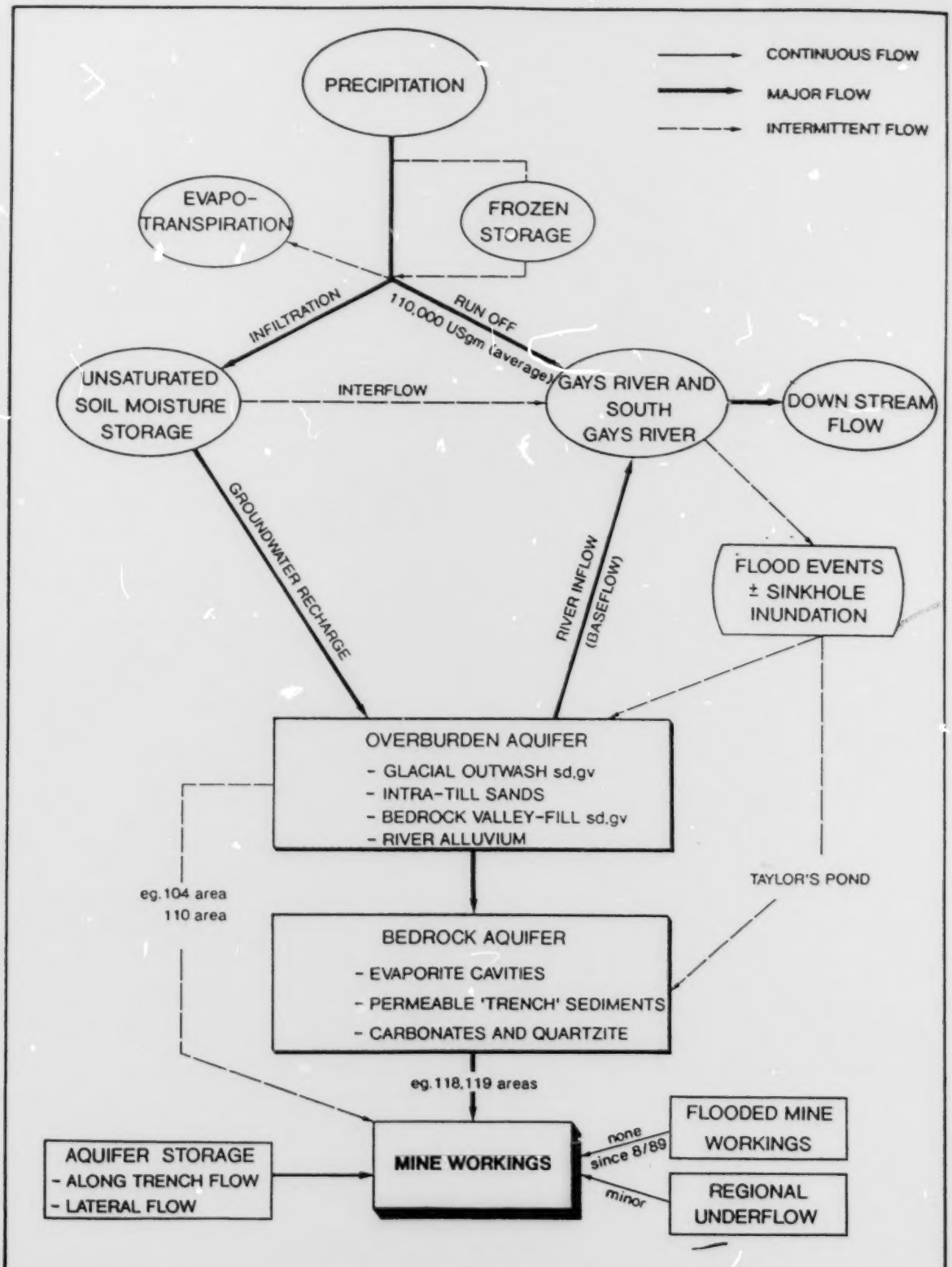


GAYS RIVER DEWATERING – CENTRAL MINE AREA WATER LEVELS FIG. 3



GAYS RIVER DEWATERING – TOTAL MINE WATER DISCHARGE RATE

FIG. 4



WESTERN MINING CORPORATION LIMITED - EXPLORATION DIVISION			
Map Ref.		GAYS RIVER MINE DEWATERING AND WATER INFLOW PREVENTION STUDY	Scale
Date	FEB 1991		Figure No. 5
Author	G.MEYER		Plan No. 10 010-02
Revised		WATER FLOW SUMMARY	

direct surface infiltration from rainfall, ice and snow-thaw, and from periodic river flooding events. The tracer study was carried out during a period of low river level (RL515.50m).

It appears that high intensity rainfall events (>20mm/day) and flooding of the Gays River contributes at least 500 to 1500USgpm extra water to the mine discharge during these events. It is difficult to predict the proportion coming from each source as both high intensity rainfall events and river flooding occur at the same time. Throughout the entire year most other rainfall and thawing events continually contribute water to the Overburden Aquifer which remains saturated and then continually provides the majority of the 3500 to 4000USgpm discharged from the mine.

The Overburden Aquifer also contributes water to the Gays River (river inflow) as evident from river flows measured at two points by Martec in 1989c. This contribution is considered to be from topographically high areas to the north of the river and water flows will be from north to south. At the time of measurement the Gays River was gaining 11 000USgpm along a 1.7km section of the river.

In places the Overburden Aquifer is considered to lie directly on permeable Bedrock Aquifer and therefore contribute water directly to this aquifer. The position, size and nature of these sites are not known and requires further investigation, but are expected to be limited to only the areas where glacial-fluvial sands and gravels have replaced impermeable, clayey glacial till (Plan 10010-04).

The mine workings receive water from the Bedrock Aquifer via drain holes in the 118 and 119 areas. Flooded evaporite cavities near the trench contact and to a lesser extent, saturated permeable trench sediments, carbonates and quartzites transmit water from the saturated Overburden Aquifer to the mine workings. In the past, some water directly entered the mine workings near the 104 and 110 areas from the Overburden Aquifer. In these areas, mining deliberately went high enough to broach the base of the Overburden Aquifer and caused massive water inflow. The 110 area was sealed off with 2 large concrete bulkheads and 2 drainholes installed, but no longer contributes significantly to mine water discharge. Mining is currently proceeding in the 110 area against impermeable overburden. The 104 area was not sealed and curently contributes minor amounts of water to mine discharge.

Some water enters the Bedrock Aquifer during river flood events near Taylors Pond (Martec, 1991a).

Water inflow to the mine workings is also from aquifer storage, either as flow from evaporite cavities along the strike direction of the trench, or to a lesser extent, laterally from permeable carbonates, quartzites and from cavernous evaporites located lateral to the trench. The contribution to mine discharge from storage is not considered significant as water levels have remained reasonably static since August 1989. Any reduction in water level indicates water being removed from aquifer storage. A stable water level means equilibrium has been established between the amount of recharge to the Bedrock Aquifer and the amount of mine discharge.

Minor amounts of water enter the mine workings from regional underflow. This is water that flows from areas where the potentiometric surface is higher than the potentiometric surface at the edge of the cone of depression. The only area where this is likely to occur is in the topographically high area south of the mine area. As the Overburden Aquifer in this area is considered to be dominantly impermeable, clayey glacial till, the underflow is considered low.

2.2 Precipitation

The annual total precipitation at the Gays River Mine is considered to be 1250mm which is the average of values measured at Halifax International some 19km SW and Upper Stewiacke some 40km NE. Daily precipitation readings were collected by mine staff from Halifax International

and are presented as Figure 6 as well as documented in Appendix 1. These readings may be slightly higher than at Gays River Mine due to the higher elevation and proximity to the coast of Halifax International, but are considered useful for comparison with river levels and water inflows.

The climate at Gays River is extremely variable. Summer is of relatively short duration and produces lower precipitation. Fall is a period of increased storm activity and therefore increased rainfall, winter shows marked temperature fluctuations which produce periods of freeze and thaw, and spring is a further period of increased rainfall and coupled with ice and snow-thaw produces high river flows and increased potential for infiltration. The Fall season is the wettest time of the year.

During the past 2 years, precipitation at Halifax International has followed this pattern of high precipitation during Fall and Spring months. Summer 1990 produced 60-70% less precipitation than on average, but was followed by an extremely wet Fall which saw October recording 182% more precipitation than on average (Tables 3a and 3b). Three significant rainfall events of 42, 41 and the maximum daily rainfall for the 2 year period, 63mm occurred during this month. These rainfall events are not uncommon and are expected to occur at less than a 2 year recurrence interval, but having 3 occur in one month was considered exceptional (Table 3c). Another major precipitation event of 60mm occurred in November 1990 and others of 52mm and 46mm in December 1990, but overall these months had about their average total precipitation.

It is of interest to note that the run-off catchment area of the Gays River and South Gays River upstream of the junction between the 2 rivers is 155km^2 and that the average mine discharge of 4 000USgpm represents only 4.1% of the total average precipitation falling on the catchment area.

2.3 River Flow

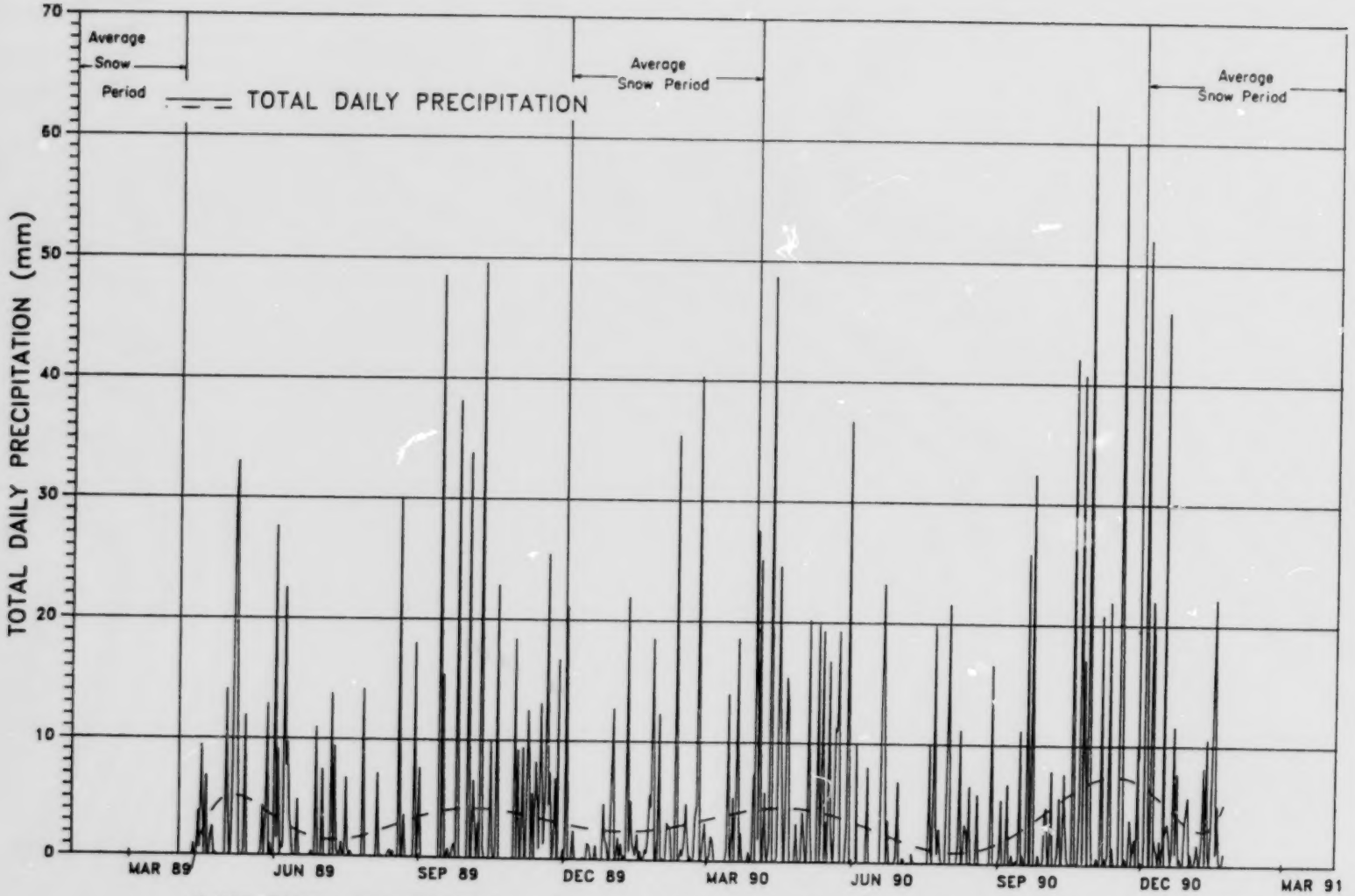
Dames and Moore in 1974a recorded river flows in the Gays River during the period 1973 to 1974. During this period they calculated the average flow to be 110 000USgpm, the minimum flow to be 1 500USgpm and the maximum flow to the 270 000USgpm. They noted that spill-out onto the river flood plain was common at flows greater than 190 000USgpm. Mine staff have noted that flooding occurred in the area near bore H5 at water levels higher than RL515.84m.

During the past 2 years, river levels have risen in direct response to major rainfall events, to periods of sustained rainfall and to periods of ice and snow-thaw. Notable flooding occurred in: Spring 1989 after 2 consecutive days of 30 and 33mm rainfall events; in Fall 1989 after a 25mm rainfall event; in Spring 1990 after 2 near consecutive days of 28 and 25mm rainfall events; and again in Fall to early Winter 1990 when 4 flooding events were caused by daily rainfall events of 63mm, 60mm, 52mm and 46mm (Figure 7).

As would be expected, high rainfall events in mid or late Summer, as occurred in September 1989, May 1990 and September 1990 produced relatively minor rises in river level. During these times surface run-off is reduced due to partly saturated soils and near surface sediments absorbing rain water and due to water loss through increased evapotranspiration. Some high river levels also occurred during Winter 1989/90 due to ice and snow-thaw.

2.4 Movement of Water Through the Overburden Aquifer

The Overburden Aquifer comprises two types of Pleistocene surficial deposits as well as younger alluvium deposited along the Gays River flood plain. The Pleistocene surficial deposits comprise a relatively impermeable over-consolidated glacial clay till which occurs mainly beneath the elongate topographic highs, and relatively permeable glacial-fluvial sands and gravels which occur mainly in topographic depressions including the depression containing the Gays River (Plan 10010-04). The Pleistocene deposits are reportedly 20 to 40m thick and perhaps thicker beneath the topographic highs (McKee et al, 1982).



GAYS RIVER DEWATERING – TOTAL DAILY PRECIPITATION AT HALIFAX AIRPORT FIG.6

TABLE 3A

HALIFAX INTERNATIONAL MEAN MONTHLY PRECIPITATION
(after Dames and Moore 1976)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	ANN
Mean Monthly Precipitation (mm)	137	128	104	108	99	79	80	108	94	118	163	179	1395
Mean Monthly Rainfall (mm)	65	59	52	86	96	79	80	108	94	117	151	113	1099
Mean Monthly Snowfall (mm)	73	691	518	218	28	-	-	-	-	18	124	673	3000

TABLE 3 B

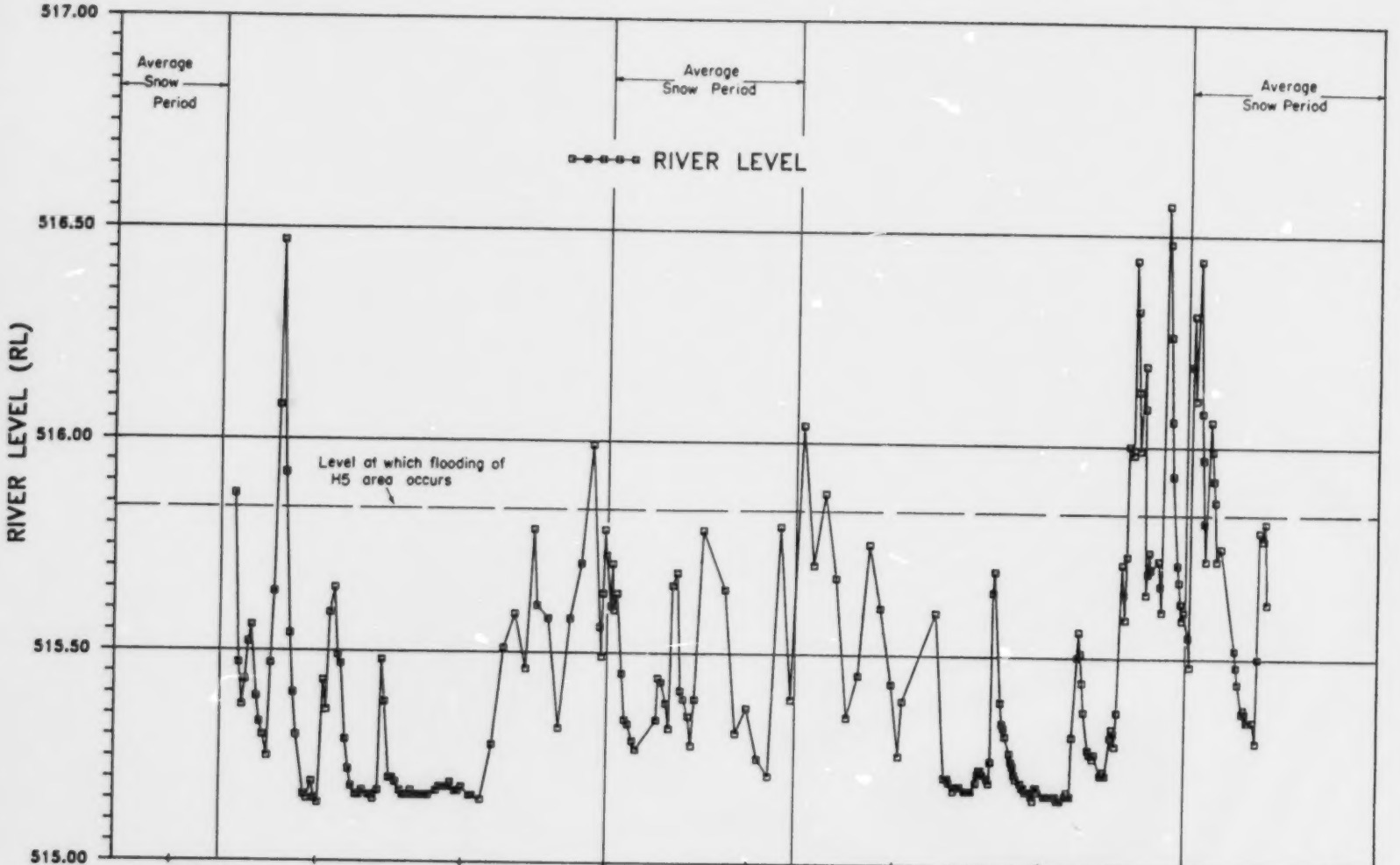
HALIFAX INTERNATIONAL PRECIPITATION
JULY - DECEMBER 1990

	July	Aug	Sept	Oct	Nov	Dec
Total Monthly Precipitation (mm)	50	69.5	85	214.5	147.7	203.6
Difference from Mean Precipitation (%)	63	64	90	182	91	114

TABLE 3 C

HALIFAX INTERNATIONAL PRECIPITATION
RECURRENCE INTERVALS

Recurrence Interval	Rainfall Intensity	24 Hour Rainfall
2 years	2.8mm/hour	67mm
5 years	3.3mm/hour	79mm
10 years	3.8mm/hour	91mm
25 years	4.6mm/hour	110mm



GAYS RIVER DEWATERING – RIVER LEVELS Fig. 7

The distribution of sand and gravel deposits in relation to clay till deposits is poorly understood. All mineral exploration holes have lumped the Pleistocene and river alluvium into one unit described as "Overburden" without reference to the lithological nature of the sediments. Most of the deep hydrogeological holes however differentiated lithologies in the Overburden Aquifer. Also a series of shallow geotechnical and sand exploration holes drilled in the period 1977 to 1981 and in 1985 provide some insight into lithological variation in the Overburden Aquifer (Jacques, Whitford and Assoc, 1981 and 1985). All of these useful holes are plotted on Plan 10010-4.

Holes drilled between the Portal and the Gays River were generally only shallow (less than 18m), but show a dominant sand-gravel lithology. The only useful deep hydrogeological hole in this area, OW1A intersected 20m of silty-sand overlying gypsum bedrock. In areas mapped as till to the east and west of this area, most holes were also drilled to less than 18m, but intersected interbedded silty clays and sands. Deep hydrogeological hole, OW2 intersected 25.9m of sandy-silt overlying 16.8m of sand and 26.6m of clay before passing into carbonate bedrock. Other deep holes in the area simply mapped the overburden as "till". Very little information on overburden lithology is available away from this central area and clearly more drilling is needed to define the permeability distribution and therefore the flow regime.

Prior to mine dewatering, water would have moved through the Overburden Aquifer from topographically high areas to the river and then discharged into the river. Mine dewatering has however reversed some of this flow causing water to flow towards areas being underdrained by the dewatering of the Bedrock Aquifer. The direction and rate of movement of this water is not completely known due to the absence of water level measurements in the Overburden Aquifer. Some component of this flow is still towards the river due to the fact that river flow is still gaining (Martec, 1989c). This component will be possibley towards the river from topographically higher areas north of the river.

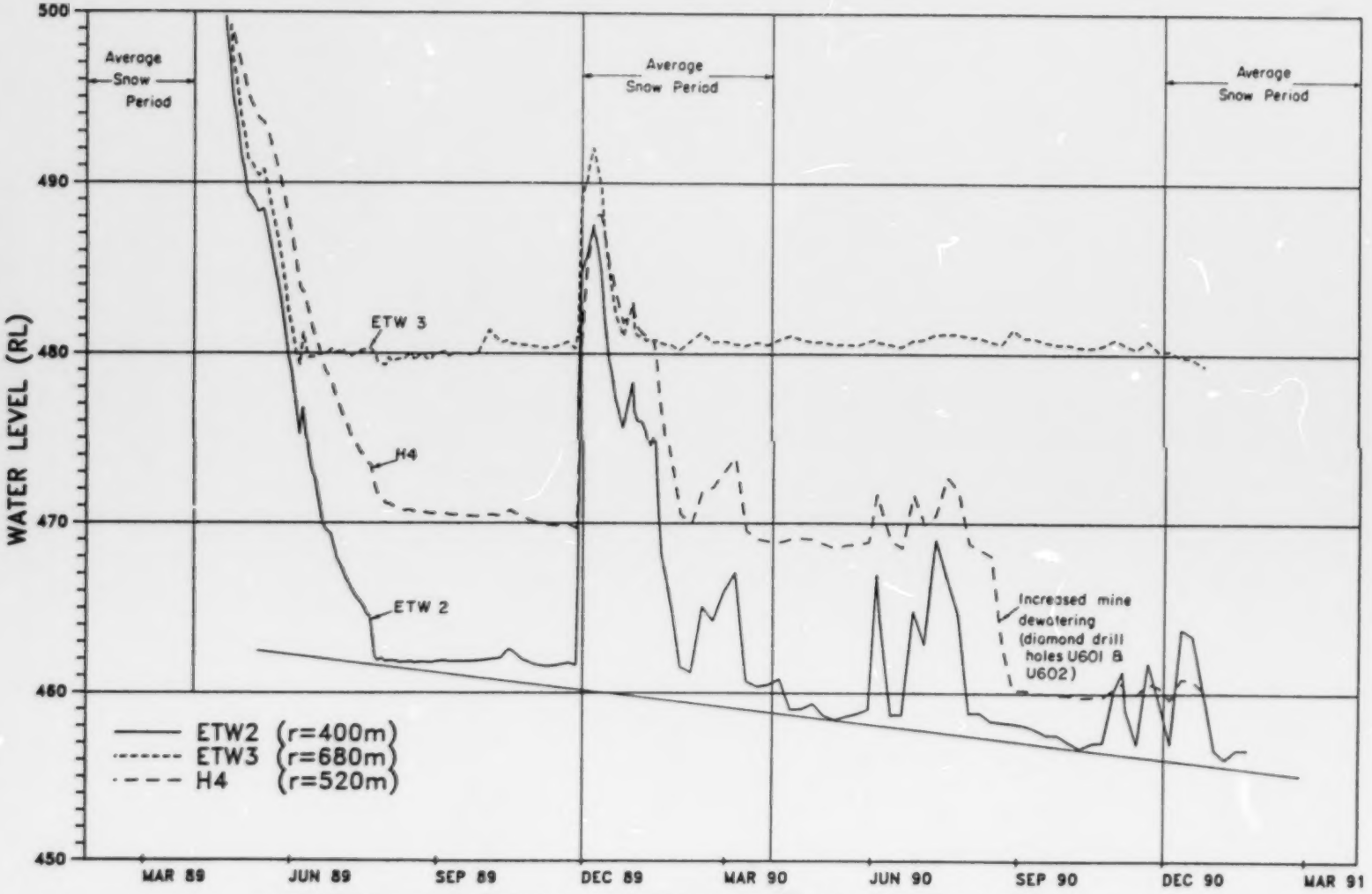
Water is entering the Overburden Aquifer from direct rainfall and snow-thaw infiltration and possibly from river flooding events. It is difficult to predict the proportion coming from the latter as it occurs at the same time as significant rainfall events. The effect of river flooding and rainfall on increased mine discharge rates is however rapid which suggests good soil permeability in either overbank flood areas or in areas overlying the glacial-fluvial sediments.

Flow rates through the Overburden Aquifer are not known due to lack of water level data, but are expected to be lower during winter when water levels drop in response to decreased infiltration. Flow rates during the remainder of the year are expected to be reasonably constant.

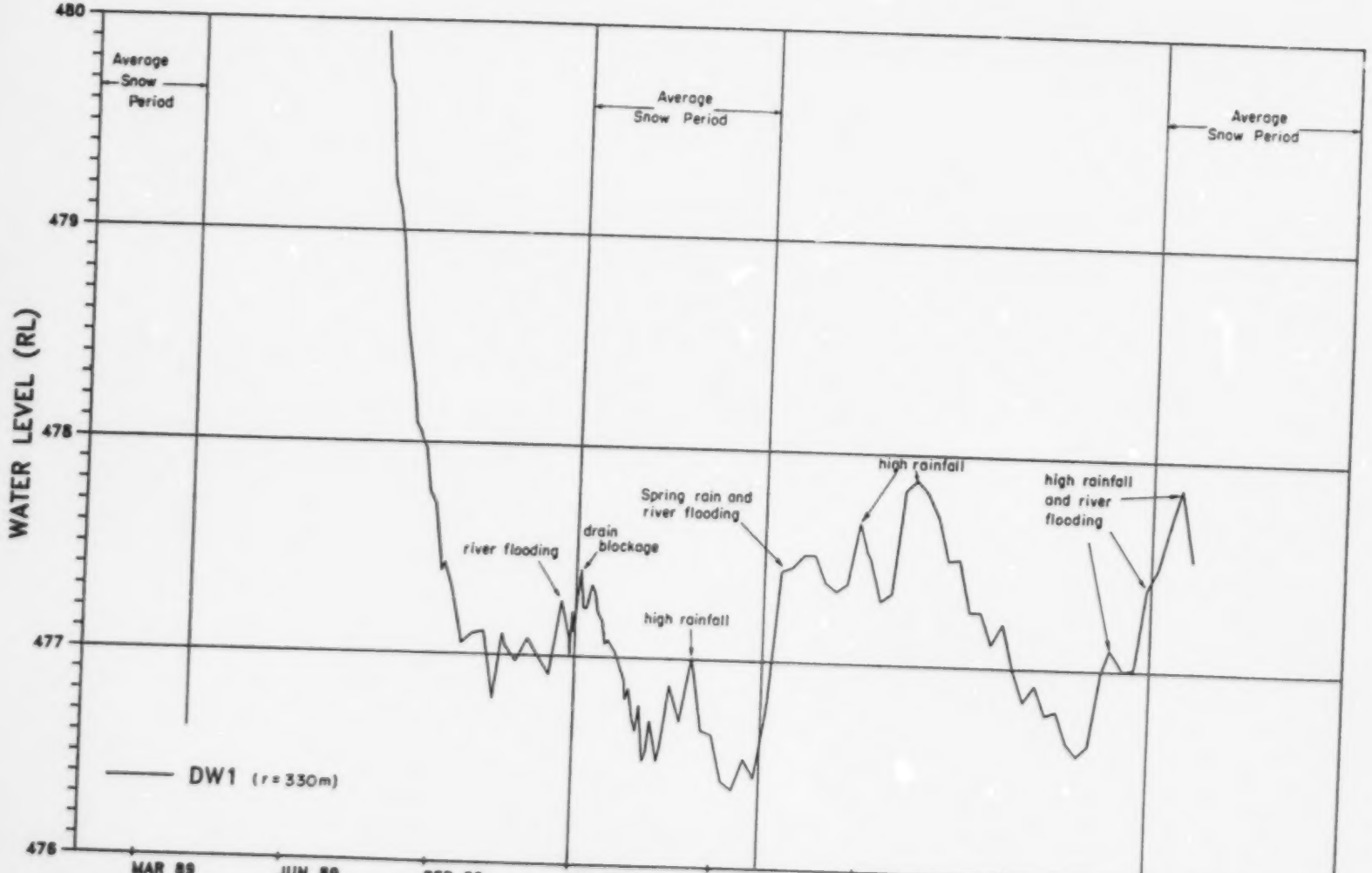
2.5 Movement of Water Through the Bedrock Aquifer

The movement of water in the Bedrock Aquifer is better understood than movement of water in the Overburden Aquifer. Water levels in the Bedrock Aquifers have been recorded in up to 15 holes over the past 2 years. In addition, water pressures have been measured on a daily basis in the 118 area drainholes. This number of holes has been reduced to only 6 useful bores due to water levels dropping beneath the piezometer tubes due to holes blocking. All bores were constructed to isolate the Bedrock Aquifer from the Overburden Aquifer and give valuable insight into understanding groundwater flow in the Bedrock Aquifer. Hydrographs of the 6 bores have been plotted into 3 groups representing water levels in the Central, Western and Eastern parts of the mine area (Figures 3, 8 and 9). Recently bore H4 became blocked at RL458.3m and has been removed from the list requiring daily or weekly monitoring.

As shown on Figure 5, most water enters the Bedrock Aquifer from places where it is hydraulically connected to the Overburden Aquifer. Martec in 1991a were able to prove using dye tracers, that water directly enters the Bedrock Aquifer and mine during flood events through outcropping karstic gypsum at Taylors Pond and the small water flows continually enter the Pond throughout the Spring and Fall seasons and the Pond is known to fill after significant rainfall events.



GAYS RIVER DEWATERING – WESTERN MINE AREA WATER LEVELS FIG. 8



GAYS RIVER DEWATERING – EASTERN MINE AREA WATER LEVELS FIG. 9

Other areas where Bedrock Aquifers outcrop and therefore could directly contribute recharge from rainfall, snow-thaw or flooding are near Moshers Quarry, 2.5km east of the Portal and near the South Gays River 1.5km SW of the Portal. The former is a dolomite quarry but adjacent gypsum outcrop may be a more permeable environment than the latter which is an area of carbonate outcrop. The quarry should also be tested with tracers to determine the contribution to mine water discharge.

Water levels in the Bedrock Aquifer vary in response to drainage, river flooding, ice and snow-thaw and rainfall. Water level rises up to 40m have occurred near the central part of the mine near the pumping centres at 118 and 119 (Figure 3). Equally dramatic, but somewhat lower rises occurred simultaneously in bores ETW2 (up to 25m rise), H4 (18m) and ETW3 (12m) at locations progressively west of the main pumping centres (Figure 8).

Levels in bore H4 dropped 8m in August 1990 in response to draining 2 diamond drill holes, U601 and U602 which were drilled into the trench/ore contact near H4. This is a useful drop in water level and drilling additional drainholes in this area is needed to reduce the level further. Apart from the periodic rises, water levels have continued to reach lower levels in hole ETW2 and H4, but not in ETW3 which has reached a static equilibrium level. This means that a small volume of water is still being removed from storage in the central area of the mine, but the overall Bedrock Aquifer is being recharged at almost the same rate as it is being drained. This steady recharge causing the stationary water levels in ETW3 is not to be confused with periodic recharge events that cause periodic, but temporary water level rises and consequent increases in mine discharge rates. The steady recharge is the movement of water into the Bedrock Aquifer from a possible wide area of overlying saturated Overburden Aquifer sediments while the periodic recharge is a pulse of extra water getting into the Bedrock Aquifer as a response to specific rainfall, thaw and river level events.

Water levels in the Bedrock Aquifer to the east of the 118 and 119 area near hole DW1 respond quite differently to water levels in the central and western part of the mine. Water level fluctuation is much less (generally less than 1m) and the dominant response is due to high rainfall and high river levels (Figure 9). The major drainhole blockage that occurred in late November 1989 hardly had any affect on water levels in hole DW1. The low amplitude of water level fluctuation is due to the low permeability of carbonates near hole DW1 and the dominant recharge response is due to the proximity of DW1 to the recharge area. This is not to say that other areas cannot recharge the Bedrock Aquifer, but it does suggest that water level rises are occurring as a response to periodic recharge events from the north and east, but not west of the 118 and 119 area. These periodic recharge events are therefore considered to be from the glacial-fluvial sand-gravel unit primarily in the area between the Portal and river and probably also extending to the north of the river and along the river flood plain (Plan 10010-04).

The extent of the recharge zone will only be known after the geohydraulic properties of the Overburden Aquifer are more fully understood.

Dames and Moore in 1980a reported the results from a 15 day pumping test completed using DW3 as the pump bore. The results were re-analysed in this report and plots included in Appendix 2. The pumping rate was not reported, but was assumed to be between 500 and 700USgpm as this was the known capacity of the pumps used at the time. Water levels in DW3 provide the most reliable results as measurements were read from as early as 2.5 minutes. Other holes had their first measurements read after 100 minutes elapsed and were therefore less reliable.

The transmissivity (aquifer hydraulic conductivity x aquifer thickness) of the Bedrock Aquifer near DW3 was estimated to be 340 to 470m^2/day. The transmissivity between DW3 and OW1A was 370 to 520m^3/day and the transmissivity between DW3 and H4 was 600 to 840m^2/day. The higher transmissivity measured towards H4 indicates higher hydraulic conductivity in a westerly direction.

Other bores that were in hydraulic connection to DW3 in 1980 were H2 and OW1 and possibly H3 and H7 (Appendix 2).

The total mine discharge at Gays River is therefore considered to be derived partly from dewatering of the Bedrock Aquifer, but mainly from a steady recharge from the Overburden Aquifer. Periodic, but temporary rises in the discharge rate are clearly due to periodic recharge events occurring through the Overburden Aquifer from rainfall, thaw and river flooding events (Figure 10). Without the periodic recharge events the mine discharge would be expected to stabilise at between 3000 and 4000USgpm except if the properties of the Bedrock Aquifer or the nature of the connection between the two aquifers was being altered by solution of gypsum or the formation of permeable sinkholes. These aspects are discussed in the next two chapters.

3. HYDROGEOCHEMISTRY

The water chemistry at the Gays River Mine reflects the proximity to recharging surface waters and proximity to highly soluble gypsum deposits. The high HCO_3 content of water discharging from the mine indicates the proximity of surface water recharge while the high Ca and SO_4 content indicates contact with gypsum as water migrates from the Overburden Aquifer to the drainholes and mine pumps.

Water chemistry was measured from early, deep hydrogeological holes as well as over the past 2 years, on a regular basis from samples of total mine discharge (Appendix 3). Holes drilled in 1974 give us an insight into the water chemistry prior to mining. From Table 4 it can be seen that samples taken from glacial sands had low SO_4 contents generally in the range 15 to 600mg/l while samples taken from the Bedrock Aquifer had high SO_4 contents generally in the range 1300 to 1480mg/l. Exceptional was the high SO_4 water (1480mg/L) from the Overburden Aquifer in hole H5 which tends to indicate proximity to gypsum bedrock. Also the low SO_4 water (455mg/l) from fractured carbonates in hole H1 which indicates this water has not been in contact with gypsum. In comparison, Gays River has SO_4 contents which range from a low of 60mg/l in Winter when cold temperatures and slower water movement are less conducive to dissolution of gypsum, to a high of 400mg/l in Summer.

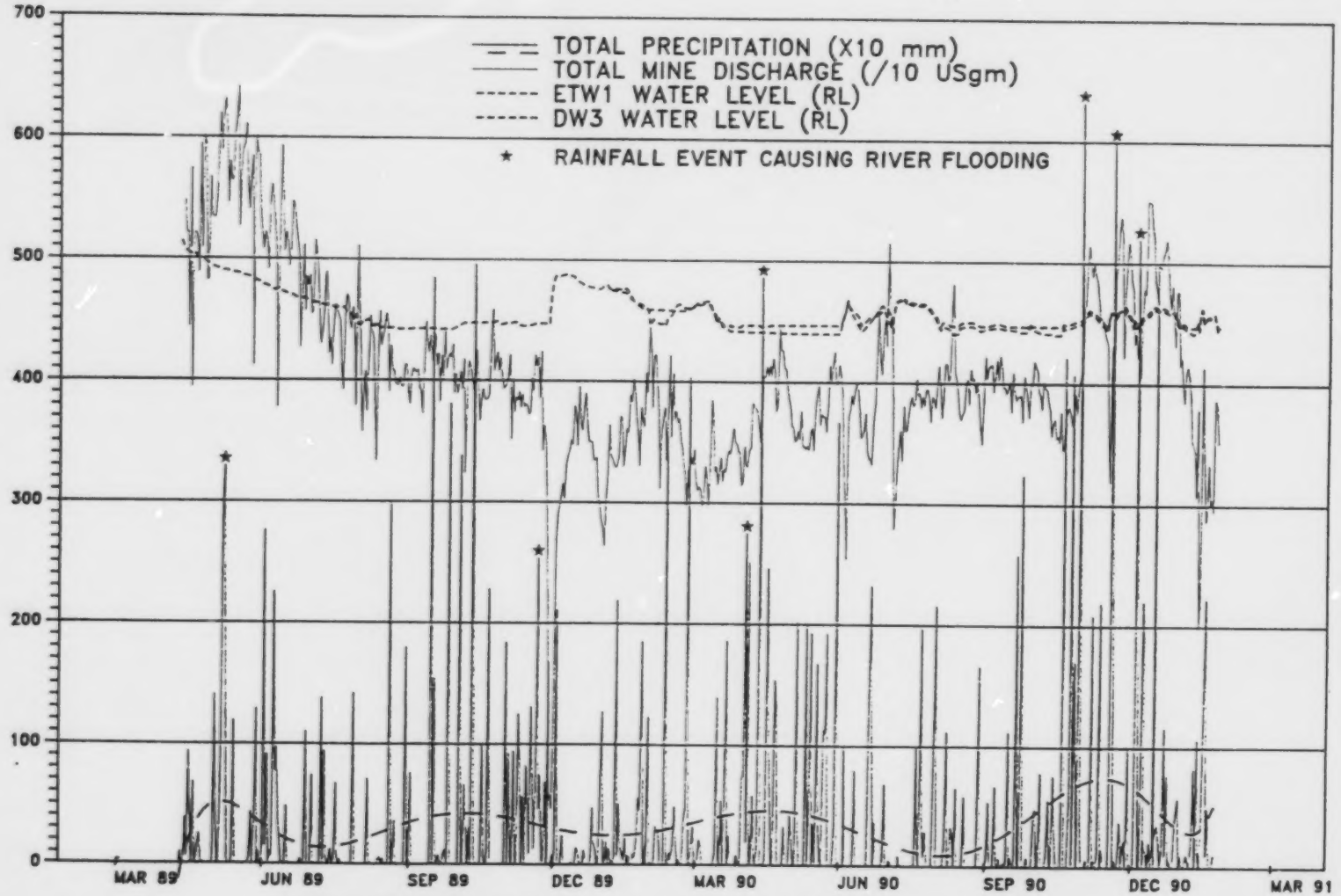
Water chemistry had not altered significantly from 1974 to 1980 when Dames and Moore installed the DW series of deep hydrogeological bores. SO_4 content was low in the Overburden Aquifer and in the range 50 to 524mg/l and high in the Bedrock Aquifer and in the range of 1325 to 1465mg/l. The SO_4 content of mine discharge varied from 1250 to 1500mg/l during the IOL mining period (McKee et al, 1982).

The variation in SO_4 and HCO_3 from mine discharge since the mine was re-opened in 1989 has been plotted on Figure 11. SO_4 varies in a reverse cycle to river SO_4 content by being highest in Winter and lowest during the Spring thaw period. By careful comparison with rainfall, river levels and mine discharge rate it is evident that decrease in SO_4 is due to dilution from meteoric water. SO_4 contents as low as 1000mg/l may indicated 30% dilution of water which normally have 1400mg/l SO_4.

Variation in HCO_3 from mine discharge is somewhat more complicated than SO_4 with a number of unaccountable highs and lows occuring before 1990 (Figure 11). Variation since early 1990 has been more sympathetic with SO_4 variation indicating the effect of dilution from meteoric water.

Variations in pH was also plotted to see if HCO_3 content was pH controlled (Figure 12). All waters had pH above the HCO_3/H_2CO_3 stability line.

Variation in total suspended solids and conductivity shows no sympathetic relation to SO_4 and HCO_3 (Figure 13). The significance of increased conductivity after June 1990 is not known.



GAYS RIVER DEWATERING – VARIOUS HYDROLOGICAL PARAMETERS FIG. 10

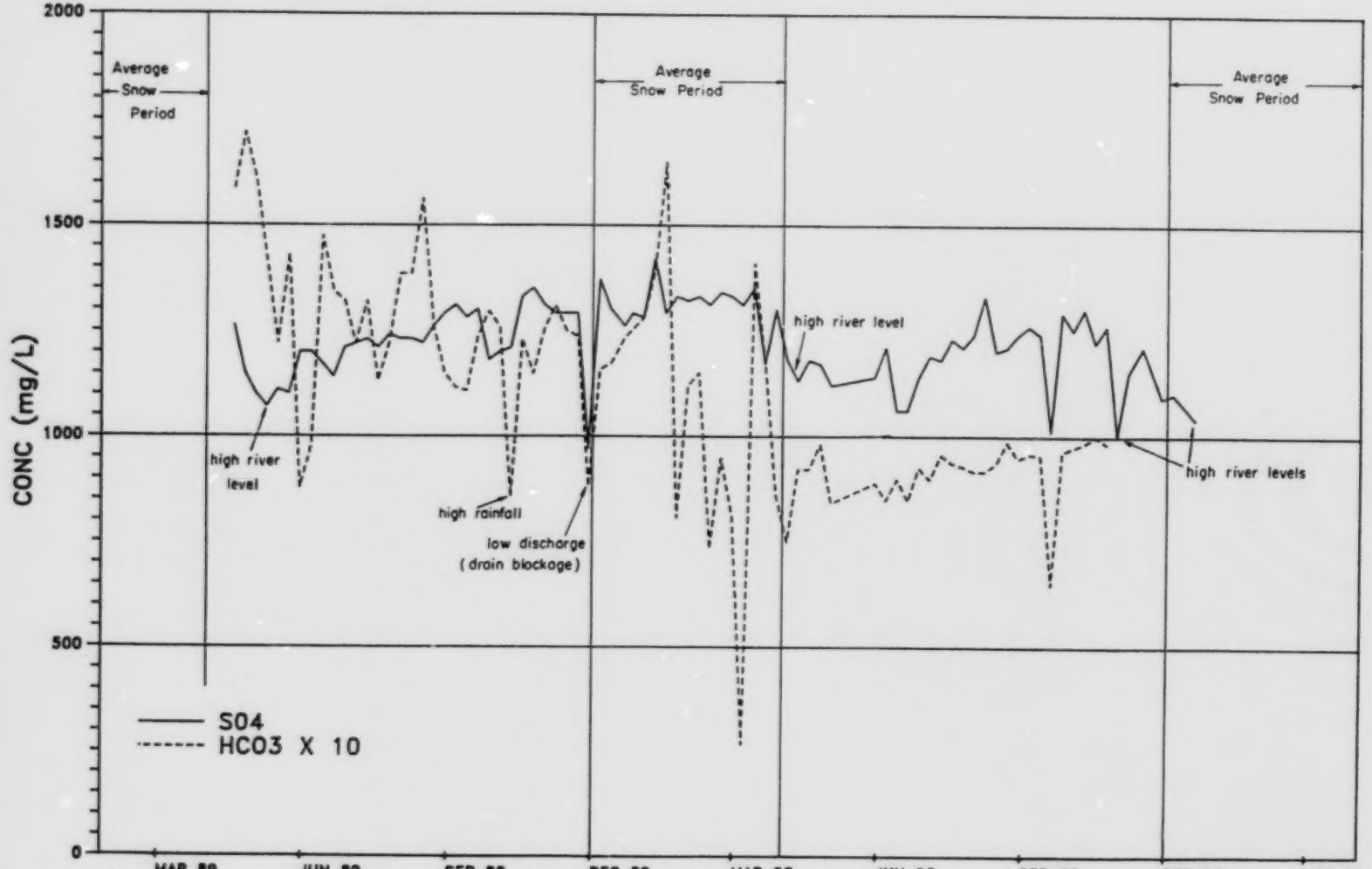
TABLE 4

GROUNDWATER ANALYTICAL SUMMARY

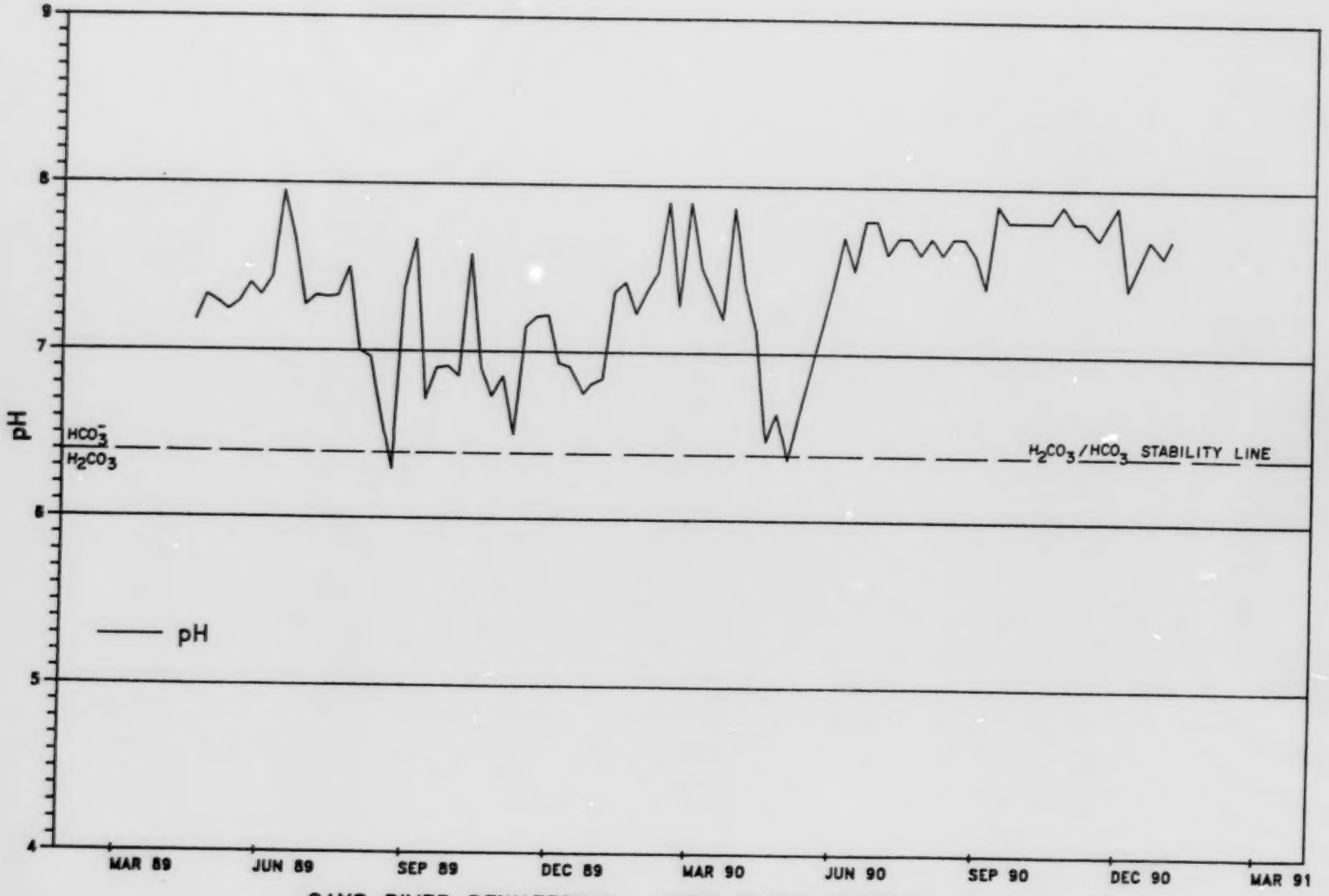
BASIC WATER ANALYSES

GAYS RIVER PROJECT

LOCATION	SAMPLE NO	SAMPLE DATE	AQUIFER NAME	pH	EC@25C umhos/cm	TSS	Na	Mg	Ca	K	Cl	SO4	HCO3	CO3	NO3
										mg/L					
#106D DR	#106D DR	23-01-1980		7.30	610		6.6	17.30	240.00	0.60	9.6	524.00	181.00		
#107 DR	#107 DR	23-01-1980		7.25	1525		28.0	14.60	576.00	1.20	26.0	1402.00	126.00		
#119 DR	#119 DR	23-01-1980		8.00	1150		5.7	7.20	569.00	33.00	12.0	1465.00	76.80		
DECLINE	DS-3	18-09-1974	GLACIAL SND	7.50	567		6.0	4.20	31.40	1.20	6.0	50.00			
DW-3	DW-3	16-03-1980	EVAPORITES	7.60	1500		6.9	16.00	540.00	0.80	8.2	1325.00	100.00		
GAYS RIVER		17-01-1980		6.60	1120		3.6	1.50	21.00	0.40	6.8	44.00	11.00		
H-1	H1	18-07-1974	CARBONATE	7.50	1050		23.0	25.80	178.00	3.40	18.0	455.00			
H-2	H2	08-08-1974	CARBONATE	7.80	2140		15.0	21.90	553.00	1.90	11.0	1300.00			
H-3	H3	28-08-1974	?EVAPORITES	7.70	2440		29.0	19.90	514.00	2.20	36.0	1450.00			
H-4	H4	22-08-1974	?CARBONATE	7.70	2040		12.0	32.40	523.00	1.10	14.0	1400.00			
H-5	H5	25-09-1974	OVERBURDEN	6.30	1840		17.0	47.40	434.00	3.70	9.0	1480.00			
H-6	H6,1	02-09-1974	GLACIAL SND	8.00	200		4.8	4.00	26.00	0.50	4.0	15.00			
H-6	H6,2	06-09-1974	" "	7.90	1430		13.0	27.10	226.00	1.10	9.0	600.00			
WCI-GR-P1	P1SURF	31-08-1989	OVERBURDEN	7.40	480		5.3	7.70	67.00	0.70	4.3	25.00			
WCI-GR-P2	P2SURF	31-08-1989	OVERBURDEN	8.10	1055		19.0	17.00	130.00	1.70	7.6	350.00			
WCI-GR-P6	P6SURF	22-09-1989	OVERBURDEN	7.40	1630		10.6	17.90	233.00	1.40	11.0	590.00			

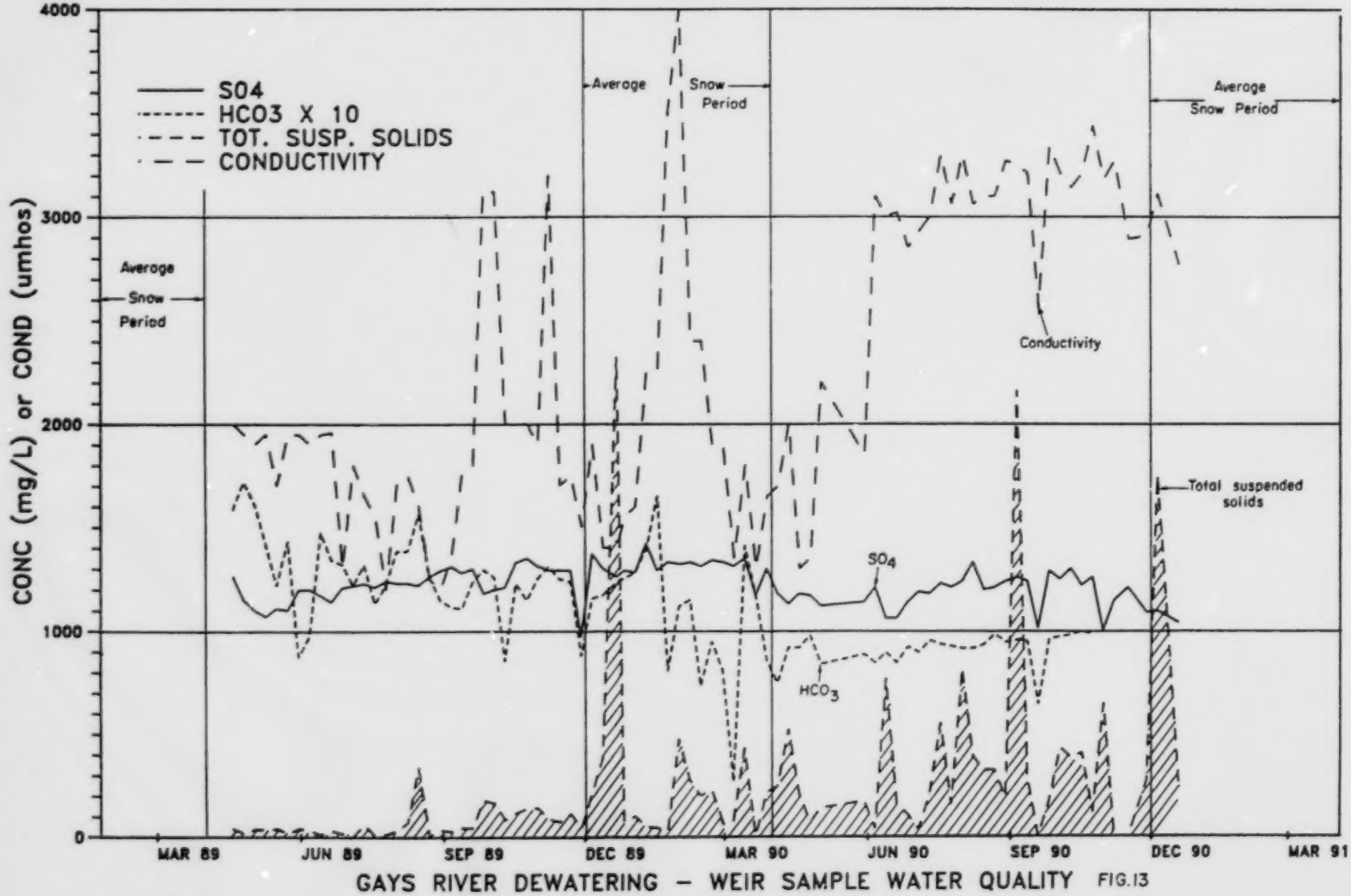


GAYS RIVER DEWATERING – WEIR SAMPLES WATER QUALITY – S04 & HCO3 FIG. 11



GAYS RIVER DEWATERING – WEIR WATER SAMPLES – pH

FIG. 12



GAYS RIVER DEWATERING – WEIR SAMPLE WATER QUALITY FIG.13

Creation of solution channels by groundwaters dissolving gypsum and thereby increasing flow rates to the mine has been a concern from the early mining period. Solution channels in gypsum were noted in the 118 and 119 area and flows that were originally trickles increased to 500-1000USgpm. These were apparently promoted by surface drillholes that did not cement-off the Overburden Aquifer allowing direct flow to the evaporite. Although these incidents can still occur, it is considered that flow rates to the mine have remained reasonably static at an average 4000USgpm during the past 2 years. Flow rates greater than 4000USgpm occurred only during the initial dewatering period and still occur during temporary high recharge periods. Flow dropped to an average 3500USgpm in both the 1989/90 and the 1990/91 Winter season (Figure 4). Furthermore it can be calculated that the difference in total dissolved salts between river water and discharge water requires dissolution of 6000m^3 of rock each year. If this is occurring over a large area, as is suspected, the impact on mining is not significant. If this is in areas close to the contact with the Overburden Aquifer then surface sinkholes will form as overburden sands drop into the cavities.

The continual rise and fall of water levels, as has occurred over the past two years is of some concern as each cycle of water level rise could dissolve more gypsum, particularly from the central part of the mine. Increased drainage and control of drainhole blockages should improve this situation.

A study of the geohydrogeology of the Overburden Aquifer, and in particular the nature of the basal contact is required to determine potential problems caused by gypsum dissolution. By preventing water flowing from the Overburden Aquifer to the Bedrock Aquifer, solution effects will be reduced and formation of sinkholes also reduced.

4. SINKHOLES

Sinkholes and the possibility of massive river water diversion through them has been cause for concern at Gays River since they first developed on the land surface in the 119 and 104 areas during and after the IOL mining operations (McKee et al, 1982). The sinkhole near the 104 area developed after the mine was allowed to flood and was a result of overburden sediment becoming re-saturated.

During pre-closure investigation sinkholes were also found in the bed of Gays River (Martec, 1981).

McKee in 1982 reported some correlation between sinkhole activity and heavy rain, overbank flooding, spring thaw, initial pumping at 118, drilling and use of underground drainholes, total drainage of 119 area and increased sediment load into the 118 and 119 sumps. Over the past 2 years, sinkhole activity has re-occurred in the 119 area, but appears to have been brought under partial control by filling with waste rock and capping with clay. Some new sinkhole activity has been noted recently north of the river.

Sinkholes form when loose overburden sands and gravels collapse into karstic gypsum cavities. The movement of loose sediment is caused by sediment being removed from underground drainholes and by the increasing size of gypsum cavities and channelways caused by dissolution of gypsum. The problem appears to be confined to the areas containing glacial-fluvial sediments and not to areas dominated by glacial clay till (Plan 10010-04).

To prevent loose sediment transferring from the Overburden Aquifer to the gypsum cavities and to reduce cavity and channelway widening it will be necessary to reduce the inflow of water from the Overburden Aquifer to the Bedrock Aquifer. To prevent sediment escaping from the drainholes it may be necessary to redesign the drainholes as discussed in the next chapter. Furthermore, mining and drilling operations should be designed to minimise direct transfer of loose overburden sediments to mining operations.

5. DRAINHOLES

Two successful drainage holes were installed by IOL in the 118 area at an elevation of 407.5m. These were angled upwards at 45° and intersected cavities at RL420m. They were completed by firmly bolting a 125mm collar pipe to 1.5m depth, drilling a 50mm pilot hole to the quartzite/carbonate contact, reaming this to 100mm and then drilling a 50mm pilot hole to the water filled gypsum cavities. A 100mm valve was added to one hole with a gas driven auto shut-off mechanism in event of power failure (McKee et al, 1982). This is not currently in use.

Westminer (Canada) subsequently reamed one of the drainage holes to 125mm diameter and drilled several 100mm wide drainholes. These latter drainholes were completed with HQ size drill rods left partly pushed into the gypsum cavities in an effort to prevent build up of debris near the hole entrance. Two of the latter holes made significant quantities of water.

Since May 1990, water pressures have been measured from one of the 118 area drains. These have been plotted on Figure 14 and show periods of low pressure occurring when drains block and periods of high pressure when water levels in the Bedrock Aquifer rose as a consequence of blockages and temporary recharge events. The normal operating pressure appears to be between 35 and 45psi. This pressure is the driving force behind the discharge and is controlled by the open drainage area (ie. the number and diameter of each drain hole). Increasing the number of drainholes will cause initial higher discharge rates and cause the operating pressure to drop therefore aquifer water level to drop. As operating pressure decreases, the discharge rate will also decrease until a new equilibrium has been reached between the discharge rate, pressure and aquifer recharge rate.

Apart from increasing the number of drainholes, the second problem is current drain designed allows release of fine sediments from cavernous gypsum and subsequent formation of surface sinkholes. Although adding screens will eliminate discharge of sands and gravels there are a number of other problems associated with screens that need to be considered. These are:

- potential blockage and subsequent screen collapse caused by very fine sands and silts, and
- encrustation of screens with gypsum. The gypsum in solution is near saturation and has been noted to deposit on the floor of the 118 drive.

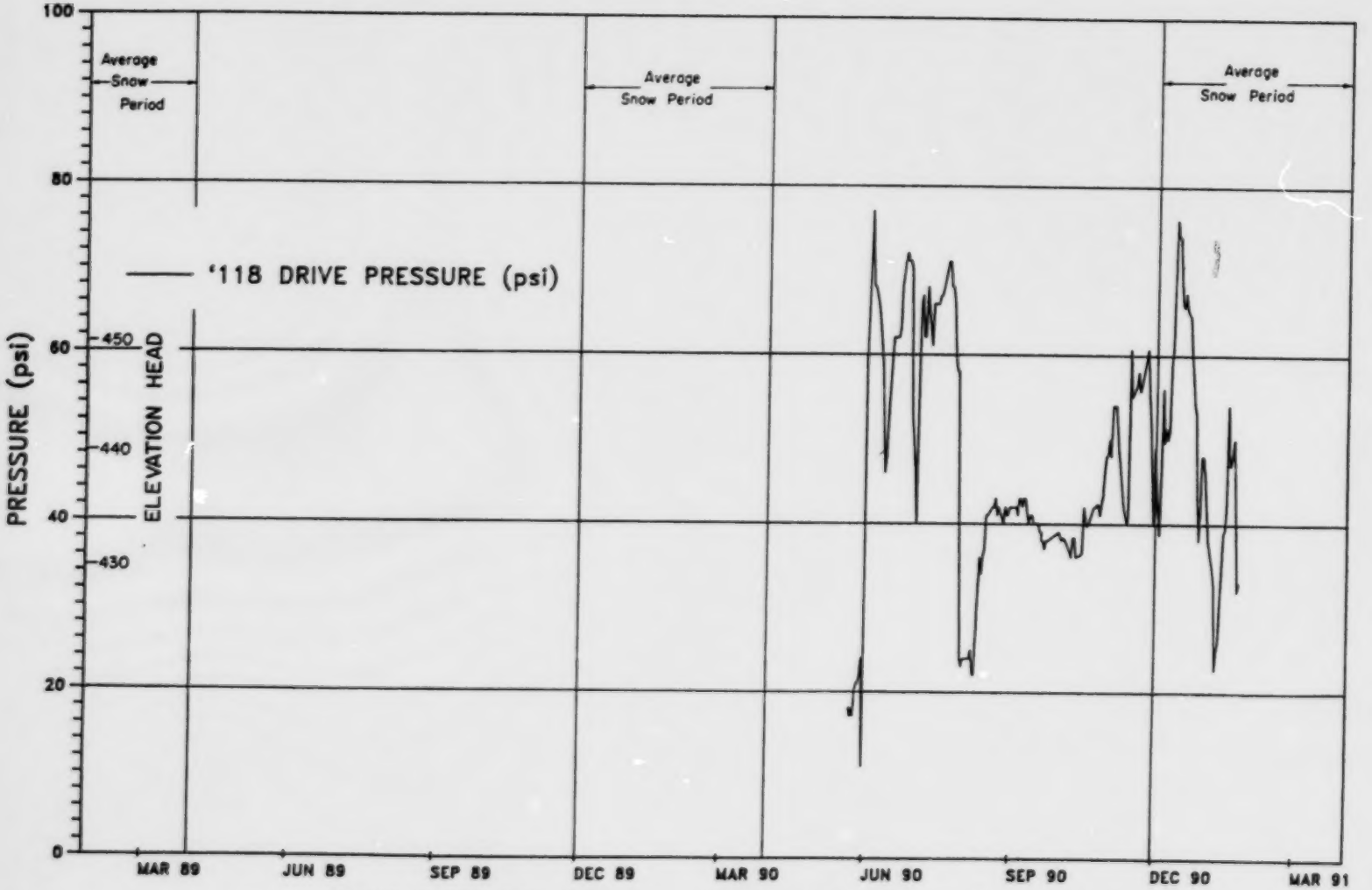
To overcome these problems it is proposed to monitor and sample the discharge water on a daily basis to determine when and how much suspended sediment comes through the drains. If more than 5% sediment is detected this should be sampled to determine the variation in grainsize. With this information a drainhole completion programme can be designed with properly sized stainless steel wire-wound screens. Also a decision can be made whether to include a graded gravel pack behind the screens or to develop with natural cavity-fill sands and gravels.

To eliminate problems caused by build-up of gypsum on the screens it will be necessary to complete each hole with suitable valves to allow injection of acid to wash the screens.

6. MONITORING PROGRAMME

A very effective monitoring programme has been in operation at Gays River for the past 2 years. This program measures or records water levels, flow rates, climatic data, pressure data and water quality at daily or weekly intervals (Appendix 1).

Because some monitoring holes are blocked and no longer of use and others respond slowly, this report suggests modifications to reduce some readings from daily to weekly and some to monthly periods (Table 5). The most important water levels are those close to the pumping centres (DW3) and close to mining areas (ETW2 and ETW3) which should continue to be measured on a daily basis. Other holes further from the pumping centre either react sympathetically with DW3 or react



GAYS RIVER DEWATERING – WATER PRESSURE AT '118 DRIVE FIG. 14

TABLE 5

PROPOSED MONITORING PROGRAMME

Location/ Hole No	Daily	Weekly	Monthly	Comments
OW1A			X	Blocked at RL 475.7m
OW2			X	Hole blocked
OW3			X	Very slow reaction rate
OW6			X	Shallow bore, probably blocked
DW1		X		Slow reaction rate
DW2			X	Probably blocked
DW3	X			
ETW1			X	Blocked at RL 446.7m
ETW2	X			
ETW3	X			
ETW4		X		Very slow reaction rate
H4			X	Blocked at RL 458.3
H5		X		Overburden Aquifer
H7			X	Blocked at RL 475.9m
DDH773			X	Blocked at RL 486.2m
DDH738			X	Blocked at RL 471.0m
WCI-GR-P6		X		Overburden Aquifer
Bricked Well		X		
Intervale Well		X		
Mine Water Level		X		
Gays River Level	X			
Mine Disch Rate	X		X	
Mine Disch TDS, SO_4, HCO_3		X		
Mine Disch Full Analyses				
Halifax I. Precip.	X			
Snowfalls	X			
Freeze/Thaw Days	X			
118 pressure	X			
118 TSS	X			

very slowly due either to constant recharge conditions or because they are open to rocks with low hydraulic conductivity. These holes can be measured on a weekly basis.

Recording precipitation at Halifax International should continue on a daily basis, but should be supplemented with daily records of snow-fall and daily records of freezing and thawing days. These will allow more meaningful comparison between precipitation, river levels and recharge as snow-falls should not recharge the aquifer on freezing days, but could recharge the aquifer later on thawing days.

It will be useful to continue measuring SO_4 and HCO_3 content and adding total dissolved solids content of water discharging from the mine on a weekly basis to determine if more gypsum is being dissolved from the Bedrock Aquifer. This data would be compared with data collected over the last 2 years to see how it has varied on a season to season basis. A full analyses could be measured every month to determine if environmentally unacceptable chemicals were discharging to the Tailings Pond.

I also recommend the purchase of a portable conductivity meter to measure water electrical conductivity (EC). A comparison can then be made with total dissolved solids, SO_4 and HCO_3 to see if analyses of these constituents can be replaced by the more economical EC measurements.

To help trace water flows I recommend that additional water samples be collected from as many sources as possible. Sources would include the river, both upstream and downstream; water samples bailed from active, open hydrogeological bores (OW3, DW2 and DW3, ETW2 to ETW4 and H5) and; water from underground seepage and inflows including bores in the 118 area. Samples should be analysed for the major ionic constituents Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl and NO_3 and plotted on Schoeller Diagrams and Trilinear Diagrams or similar to demonstrate trends or changes in chemical concentration that could indicate migration of water from the surface environment to the mine. Examples of Schoeller and Trilinear Diagrams using most available historic data are included in Appendix 3. Samples should be taken on a monthly basis for a limited period to determine the overprint of seasonal trends.

7. CONCLUSIONS

Mine water problems have caused disruption to mining and prevention of access to high grade ore since Imperial Oil Company Limited started mining in 1979. Westminer (Canada) have succeeded bringing water levels down to RL 440m, but still suffer during times when underground drainholes block or when high precipitation events coupled with high water levels in the Gays River cause water inflow to the Bedrock Aquifer to exceed the mine discharge rate. The immediate solution to this problem is to increase the number of drainholes located in areas that can remove water from the karstic gypsum cavities. Without increasing the discharge rate, water levels in the mine will not drop below RL440 and water levels in the central part of the mine will rapidly rise following the frequently occurring high precipitation events. As part of this exercise, steps should be made towards reducing sand loss from cavities as it will reduce to the formation of surface sinkholes.

To also increase mine discharge and at the same time reduce pumping costs, dewatering bores DW3, ETW1 and ETW3 should be rehabilitated or reconstructed. These bores are capable of supplying significant quantities of water without the need for extensive reticulation and if properly designed, will not suffer sand inflow problems.

A secondary solution to the mine water problem is to prevent water from entering the karstic gypsum cavities in the first place. This requires more time and will require a study of the geohydraulic properties of the Overburden Aquifer and a study of the nature of permeable contacts with the underlying Bedrock Aquifer. The instigation of this study was the recognition that large parts of the overburden were impermeable, over-consolidated, clayey till deposits and that the main conductor for water inflow was the less extensive, glacial-fluvial sands and gravel deposits. If these can be dewatered or perhaps locally grouted, water inflows to the mine will be significantly reduced.

Over the past 2 years, mine staff have collected hydraulic and hydrochemical data and have made a positive contribution to our understanding of the geohydraulic nature of the Gays River area. The total mine discharge was shown to decrease from 6000 to 4000USgpm during the first 4 months of dewatering as water was removed from flooded mine workings and from saturated bedrock aquifers. Discharge rate has then remained steady at 4000USgpm except during Winter months when the average flow dropped to 3500USgpm; during periods of high precipitation when flow rates increased by 500 to 1500USgpm, and; during times when drainholes blocked and discharge rates dropped to as low as 500USgpm. The low discharge rate during Winter months is due to reduced infiltration caused by ground freeze and some water being held in temporary storage as ice and snow cover.

The overall steady discharge rate and the fact that water levels in most observation bores have reached a steady lower limit implies that most water is entering the mine by a steady recharge from the Overburden Aquifer to the Bedrock Aquifer. High rainfall events cause temporary periods of increased recharge, but the steady recharge is from numerous smaller rainfall events and from snow and ice thaw which keeps the Overburden Aquifer continually saturated.

The climate at Gays River is characterised by high rainfall in Spring and Fall and a Winter period of intermittent snowfall and thaw. Rainfall events over 20mm/day intensity are not uncommon and can lead to flooding of the Gays River floodplain. This in turn leads to a rapid rise in mine water levels. It is unclear what proportion of this temporary recharge is due to direct infiltration of rainfall to the Overburden Aquifer and what proportion is due to the river flooding onto a permeable floodplain or into permeable sinkholes located on the floodplain.

A recent dye tracer test proved that water does not enter the Overburden Aquifer from the base of the river during periods of low water level. This indicated that the river does not contribute to the steady recharge rate seen in the mine, but could still contribute to the temporary periods of increased recharge during times of river flooding.

As expected, the most rapid and largest rise in mine water levels seen during temporary recharge events and times when drainholes blocked, occured in the central part of the mine near the main pumping centres. A 40m rise occurred in only 2 days after drainholes at 118 blocked and total mine discharge went down to 500USgpm. The most significant water level rises in the past 2 years have been caused by blockages, but from November 1990 to January 1991 four rises amounting to between 18 and 20m occurred following high precipitation and river flooding events. After each period of water level rise, mine discharge increased because the water pressure in the flooded cavities had increased helping to drive more water through the drainholes. After the pressure dropped, discharge rates dropped and water levels returned to near RL 440m.

In the western part of the mine, to a distance of 500m from the 118 drainage area, water levels gradually rise to near RL 460m in response to the blockages and increased recharge. In this area, water levels fluctuate sympathetically to water levels in the central area. Beyond 500m, to a distance of 680m, water levels have however remained almost static at RL 480m since June 1989 and only rose during the late 1989 mine flood. This is an indication that the recharge rate has reached an equilibrium with the discharge rate.

In the north-eastern part of the mine, at a distance of 330m from the 118 drainage area, water levels fluctuate between RL 476 and RL 478m in response to high precipitation and river flooding events. This suggests that the temporary recharge events are coming into a mine from the north-eastern direction.

The water chemistry is dominated by $CaSO_4$ which was not unexpected due to the proximity of readily soluble gypsum deposits. Water samples have been taken from total mine discharge on a regular basis and analysed for a variety of chemical species including pH, SO_4, HCO_3, Total Suspended Solids and Electrical Conductance. These results together with results from water samples taken prior to mining in 1974 and again in 1980 show that SO_4 content increases from river water to Overburden Aquifer water to Bedrock Aquifer water. Furthermore SO_4 content of these

waters have not varied significantly prior to mining in 1974. A slight rise in SO_4 from mine discharge occurs during Fall and Winter when it is expected less water is entering the mine workings and a drop in SO_4 occurs during Spring and early Summer and during periods of dilution from high rainfall and river flooding. Overall the SO_4 content of mine discharge has not increased during the past 2 years which means that the rate of dissolution of gypsum cavities and channelways has not increased.

The formation of surface sinkholes due to sand being removed from drainholes and from dissolution of gypsum cavities and channelways should be reduced by using properly designed drainholes or by using surface dewatering holes. A programme of monitoring total suspended solids and measuring particle size has been recommended to determine if drainholes should be equipped with stainless steel wire-wound screens.

8. RECOMMENDATIONS

The recommendations listed here are designed to: keep water levels in the mine below working levels; prevent sediment from discharging at drainholes, and; reduce water inflow.

a) To eliminate the possibility of recharge flow exceeding in-mine drainage flow and thereby causing water levels to rise in mine workings, I recommend that urgent attention be directed to drilling drainholes at the 832 stope (RL 425m). Several diamond drill holes may be required to intersect a reasonable cavity or series of cavities in evaporites to the north or west of the trench. It would be preferable to generate flows in excess of 500USgpm per drainage area to achieve a secure water level and to prevent water levels rising in the western area of the mine during high precipitation and river flood events and times when the main 118 area drainholes block.

b) The removal of excess water flow from the 832 area is a temporary measure until proper high volume drainholes are drilled to evaporite cavities in the 807 area (RL 435m and RL 428m), 803 area (RL 425m) and 804 area (RL 410m). The plan to continue high priority development towards these headings should continue as it will remove the threat of temporary rising water levels and enable water levels to be lowered beneath the current minimum level at RL 440m.

c) To successfully complete large diameter drainholes in the deep western part of the mine, and in particular, to determine whether stainless steel screens are required, it will be necessary to:

- monitor the quantity of total suspended solids, including sand and gravel from the 118 area drainholes. This should be done by taking a large sample (>1litre) from each drain hole at the same time pressure readings are taken. This need only apply to the 2 large diameter holes and will require initially 1 sample/hole each day. The sampling requirement may change with time as trends or variability in results becomes clear. A comment on particle size would also be useful to design the appropriate screen opening if screens become essential for the successful completion of the bore and prevention of sand caving and consequent sinkhole development. If large volumes of sediment are noted (eg. in excess of 5%), a grain size analyses using sieves should be completed as it will be clear that screens will be required at both the 118 area and all subsequent large diameter drainhole sites. Two analyses will be sufficient to design the bore completion; and

- the drainholes need to be designed to cope with the anticipated flow, the anticipated natural sand grain size, gypsum encrustation problems and the anticipated need for an artificial gravel pack. The latter requirement will depend on the natural sand grainsize variation.

d) The provision of extra dewatering capacity with lower operating costs from existing surface production and observation bores should be checked. The existing bores DW3, ETW1 and

ETW3 all could provide significant and cost-effective means to dewater the mine and provide much needed extra pumping capacity if the existing casing strings could be removed and replaced with new large diameter liners. The following steps will be required:

- Hire a downhole TV camera and check the condition of existing casing screens and blockages.

  If the screens are damaged it may not be possible to remove the casing and a new hole will need to be drilled. The drilling of new dewatering bores will represent significant cost savings to the project by eliminating the need for an extensive reticulation system.

e) A number of steps need to be taken to determine the geohydraulic nature of the Overburden Aquifer so that action can be taken to reduce the inflow that is occurring to the evaporite cavities from river flooding and rainfall infiltration. These are:

- Geophysics to determine the distribution of aquifer permeability and aquifer depth between the river and mine workings. After detailed discussion with Senior Geophysicist, Roman Tykajilo, it appears that a FEM or electrical resistivity technique would be the most appropriate depending on the amount of cultural problems such as power-lines, pipelines, fences, etc. The survey will measure the spatial variation in bulk resistivity which is then related to variation in aquifer porosity and then to aquifer permeability. The survey should also locate large (>50m wide) buried sinkholes or bedrock depressions at the base of the overburden.

- The second phase of work required to determine the geohydraulic nature of the Overburden Aquifer and the major water flow directions is to install a series of piezometers. These should be positioned in the most permeable sections of the overburden aquifer and should be strategically located near surface sinkholes and near sub-surface depressions as defined by the geophysical survey.

  The final location will depend on the geophysics results, but a suggested coverage is shown on Figure 15. The 4 areas shown are in order of priority with Area A closest to the current mining area having the highest priority.

  The cost of drilling 23 piezometers to average depth 26m has been estimated as $30 000 assuming an air-rotary rig is used. This cost does not include supervision or mobilisation and assumes that the outer casing is removed to leave only the narrow 50mm piezometers. It may be sensible to use the same drilling rig that will recondition or redrill the surface dewatering holes DW3, ETW1 and ETW3. The drilling supervisor should estimate aquifer permeability by visual inspection of samples and conduct small scale recovery tests.

- Water levels should be measured accurately in each piezometer at regular intervals of one week to establish water level contour plans. From these, a flow-net analyses will determine major sites of water inflow to the bedrock aquifers and the relative flow rate into each site.

- The action required to prevent water inflow into the bedrock aquifers will depend on the number, extent and nature of each site. Each site may need to be tested by geotechnical drilling at a cost of $125/metre or approximately $3 000/site. The alternatives available to prevent water inflow will then depend on the nature of the sediments at the bedrock interface. Such alternatives could include grouting or dewatering by pumping, but I suspect that shallow dewatering bores will be the most cost effective means of diverting water flow. Such bores are cheap to install and will save the cost of pumping water from the deep mine and also reduce the problems of sands collapsing into the underground drainholes.

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10. ACKNOWLEDGEMENTS

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APPENDIX 1

TABULATED MONITORING RESULTS

TABLE 1

WATER LEVELS, PRESSURES AND RAINFALL

APPENDIX 1

TABLE 1

WATER LEVELS, PRESSURES & RAINFALL

LOCATION : PROJECT

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
10-04-1989	25										
10-04-1989			515.87					513.90			
10-04-1989											
11-04-1989	25	1			515.22	515.24			511.07	512.93	514.30
11-04-1989											
12-04-1989	5476										
13-04-1989	5211										
13-04-1989			515.47					506.05			
13-04-1989											
14-04-1989	5211	4			510.65	510.12			505.11	507.56	508.76
15-04-1989	4436	1									
15-04-1989			515.37					503.53			
15-04-1989											
16-04-1989	5744	9			509.19	508.52			503.18	505.58	506.15
17-04-1989	3938	5									
17-04-1989			515.43					502.68			
17-04-1989											
18-04-1989	5211				507.91	507.41			502.06	504.46	504.40
19-04-1989	5211	7									
19-04-1989			515.52					503.00			
19-04-1989											
20-04-1989	5145				506.72	506.06			502.03	504.48	503.03
21-04-1989	4884										
21-04-1989			515.56					500.10			
21-04-1989											
22-04-1989	5947	2			505.16	504.71			499.69	502.20	501.78
23-04-1989	5079	3									
24-04-1989	6015										
24-04-1989			515.39					498.35			
24-04-1989											
25-04-1989	5947	0			503.30	502.79			497.09	499.21	500.17
26-04-1989	4819										
26-04-1989			515.33					496.11			
26-04-1989											
27-04-1989	4819				501.72	502.07			494.94	497.11	498.71
28-04-1989	5677										
28-04-1989			515.30					495.04			
28-04-1989											
29-04-1989	5343				500.85	501.25			493.91	496.07	497.94
30-04-1989	5340										
01-05-1989	5336										
01-05-1989			515.25					492.10			

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
01-05-1989											
02-05-1989	5529	14			499.53	500.21			491.54	493.74	496.82
03-05-1989	5857	5						491.38			
03-05-1989			515.47								
03-05-1989					498.87	499.77			490.74	492.87	496.18
04-05-1989	6199										
05-05-1989	5891							489.89			
05-05-1989			515.64								
05-05-1989					497.96	499.11			489.34	491.42	495.19
06-05-1989	6187	8									
07-05-1989	6319	30									
08-05-1989	6073	33						489.87			
08-05-1989			516.08								
08-05-1989					496.82	498.61			489.00	491.05	494.54
09-05-1989	5455	13									
10-05-1989	5804	0						488.78			
10-05-1989			516.47								
10-05-1989					496.36	498.34			488.59	490.67	494.10
11-05-1989	5636										
12-05-1989	5656							488.46			
12-05-1989			515.92								
12-05-1989					495.79	497.64			488.28	490.39	493.74
13-05-1989	6038										
14-05-1989	6157	12									
15-05-1989	6424							487.60			
15-05-1989			515.54								
15-05-1989					494.77	496.56			488.47	490.79	493.52
16-05-1989	5261										
17-05-1989	5662							487.08			
17-05-1989			515.40								
17-05-1989					494.27	495.88			487.64	489.99	493.16
18-05-1989	5913										
19-05-1989	5943							485.85			
19-05-1989			515.30								
19-05-1989					493.53	495.16			486.61	488.99	492.47
20-05-1989	6116										
21-05-1989	5623										
22-05-1989	5403										
23-05-1989	5656										
24-05-1989	5851	1						483.94			
24-05-1989			515.16								
24-05-1989					492.15	493.64			484.20	486.70	490.81
25-05-1989	4116	4									
26-05-1989	5994							482.11			
26-05-1989			515.15								
26-05-1989					491.75	493.64			483.22	485.67	490.05
27-05-1989	5884	3									
28-05-1989	5854	13									
29-05-1989	5393							480.23			
29-05-1989			515.19								

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
29-05-1989					490.63	493.64			481.23	483.76	488.72
30-05-1989	5199	1						478.24			
31-05-1989	5075										
31-05-1989			515.15								
31-05-1989					489.97	493.64			479.74	482.32	487.65
01-06-1989	5222							477.66			
02-06-1989	5161	28									
02-06-1989			515.14								
02-06-1989					489.27	493.64			478.83	481.43	486.70
03-06-1989	4909	2									
04-06-1989	5468	9						475.42			
05-06-1989	5620										
05-06-1989			515.43								
05-06-1989					488.04	493.64			476.74	479.85	484.98
06-06-1989	5491	1						473.50			
07-06-1989	5273	1									
07-06-1989			515.36								
07-06-1989					487.38	489.01			475.21	479.29	483.81
08-06-1989	5025	23						475.41			
09-06-1989	3770	8									
09-06-1989			515.59								
09-06-1989					487.43	491.75			476.78	481.20	483.57
10-06-1989	5002	10						475.09			
11-06-1989	5939	4						473.41			
12-06-1989	5554	2						472.41			
12-06-1989			515.65								
12-06-1989					486.29	490.37			474.15	479.71	482.58
13-06-1989	5061							472.06			
14-06-1989	5222							471.32			
14-06-1989			515.49								
14-06-1989					485.69	489.69			473.10	479.77	481.67
15-06-1989	5139							470.61			
16-06-1989	4936	5						470.71			
16-06-1989			515.47								
16-06-1989					485.18	489.08			472.60	479.72	481.07
17-06-1989	5090							470.32			
18-06-1989	5476							469.59			
19-06-1989	5444							468.98			
19-06-1989			515.29								
19-06-1989					484.49	489.01			470.97	479.94	480.27
20-06-1989	5263							468.19			
21-06-1989	5134							467.60			
21-06-1989			515.22								
21-06-1989					484.01	489.01			469.86	479.98	479.49
22-06-1989	5023							467.06			
23-06-1989	4263							467.43			
23-06-1989			515.18								
23-06-1989					483.77	489.01			469.56	479.92	478.95
24-06-1989	4697							467.58			
25-06-1989	5119	0						466.92			

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
26-06-1989	4569							466.77			
26-06-1989			515.16								
26-06-1989					483.37	489.01			469.31	480.18	478.52
27-06-1989	4855							466.24			
28-06-1989	4774	11						465.31			
28-06-1989			515.16								
28-06-1989					483.03	489.01			468.60	480.24	477.97
29-06-1989	4864							464.53			
30-06-1989	4542							464.29			
30-06-1989			515.17								
30-06-1989					482.69	489.01			467.87	479.98	477.30
01-07-1989	4567										
02-07-1989	5159	7									
03-07-1989	5040										
04-07-1989	4857							463.28			
04-07-1989			515.16								
04-07-1989					482.09	489.01			467.14	480.25	476.35
05-07-1989	4486							462.83			
05-07-1989			515.16								
05-07-1989					481.95	489.01			466.88	480.01	476.11
06-07-1989	4292							462.63			
07-07-1989	4388							462.27			
07-07-1989			515.15								
07-07-1989					481.82	489.01			466.50	479.81	475.77
08-07-1989	4584	14						461.89			
09-07-1989	4895							461.62			
10-07-1989	4688	9						461.36			
10-07-1989			515.17								
10-07-1989					481.43	489.01			465.97	479.81	474.94
11-07-1989	4216	1						461.19			
12-07-1989	4345	0						460.44			
12-07-1989			515.48								
12-07-1989					481.32	489.01			465.63	480.02	474.58
13-07-1989	4118							460.46			
14-07-1989	4443	1						460.29			
14-07-1989			515.38								
14-07-1989					481.03	489.01			465.45	480.10	474.25
15-07-1989	4630							460.26			
16-07-1989	4577							459.93			
17-07-1989	4531	7						459.74			
17-07-1989			515.20								
17-07-1989					480.62	489.01			465.05	480.19	473.90
18-07-1989	4489	1						459.21			
19-07-1989	4121							459.16			
19-07-1989			515.20								
19-07-1989					480.49	489.01			464.63	480.21	473.55
20-07-1989	3916	0						459.87			
21-07-1989	4464							458.99			
21-07-1989			515.19								

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
21-07-1989					480.30	489.01			464.46	480.28	473.40
22-07-1989	4706							456.90			
23-07-1989	4675							455.23			
24-07-1989	4483							454.70			
24-07-1989			515.17								
24-07-1989					479.94	489.01			462.16	480.05	472.09
25-07-1989	4421							453.58			
26-07-1989	4603							450.71			
26-07-1989			515.16								
26-07-1989					479.73	489.01			461.88	479.48	471.58
27-07-1989	4468							449.26			
28-07-1989	3788	14						453.69			
28-07-1989			515.16								
28-07-1989					479.69				462.05	479.41	471.42
29-07-1989	5115							447.80			
30-07-1989	4584							445.57			
31-07-1989	4279							445.52			
31-07-1989			515.17								
31-07-1989					479.25				461.84	479.26	471.12
01-08-1989	3573							447.35			
02-08-1989	3845							449.65			
02-08-1989			515.16								
02-08-1989					479.17				461.89	479.75	471.12
03-08-1989	4072							448.88			
04-08-1989	3738							449.78			
04-08-1989			515.16								
04-08-1989					479.11				461.86	479.48	470.98
05-08-1989	4174							449.84			
06-08-1989	4533	7						448.01			
07-08-1989	4411							446.55			
07-08-1989			515.16								
07-08-1989					478.93	489.01			461.84	479.64	470.87
08-08-1989	4326	0						445.25			
09-08-1989	3851							443.73			
09-08-1989			515.16								
09-08-1989					478.71				461.78	479.67	470.79
10-08-1989	3335							447.58			
11-08-1989	4244							444.94			
11-08-1989			515.16								
11-08-1989					478.53				461.78	479.60	470.73
12-08-1989	4573							443.30			
13-08-1989	4282	0									
14-08-1989	4365	1									
15-08-1989	4441							442.98			
16-08-1989	4555	1						443.07			
16-08-1989			515.17								
16-08-1989					478.27				461.84	480.07	470.73
17-08-1989	4470							442.87			
18-08-1989	3904							442.62			
18-08-1989			515.18								

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
18-08-1989					478.09				461.74	479.55	470.60
19-08-1989	4286	.						443.02			
20-08-1989	4085	30						443.12			
21-08-1989	4070							442.96			
21-08-1989			515.18								
21-08-1989					478.05				461.82	479.88	470.67
22-08-1989	3970							442.58			
23-08-1989	3961	4						442.78			
23-08-1989			515.18								
23-08-1989					478.00				461.81	480.01	470.63
24-08-1989	3961							441.87			
25-08-1989	4022							441.91			
25-08-1989			515.19								
25-08-1989					477.97				461.79	479.72	470.58
26-08-1989	3944							442.20			
27-08-1989	3943							442.26			
28-08-1989	4131							442.17			
28-08-1989			515.17								
28-08-1989					477.77				461.76	479.57	470.53
29-08-1989	4121							442.33			
30-08-1989	3938	18						442.15			
30-08-1989			515.17								
30-08-1989					477.74				461.82	479.89	470.55
31-08-1989	3802							442.11			
01-09-1989	4033	1						442.23			
01-09-1989			515.18								
01-09-1989					477.71				461.87	480.00	470.52
02-09-1989	4099	8						442.62			
03-09-1989	4075							442.70			
04-09-1989	4065										
05-09-1989	4088							442.94			
06-09-1989	3935							442.74			
06-09-1989			515.16								
06-09-1989					477.39				461.90	480.12	470.55
07-09-1989	3917							442.74			
08-09-1989	3723							442.66			
08-09-1989			515.16								
08-09-1989					477.43				461.83	479.83	470.49
09-09-1989	4077										
10-09-1989	4489										
11-09-1989	4314										
12-09-1989	4223										
13-09-1989	4373							442.73			
13-09-1989			515.15								
13-09-1989					477.31	500.81			461.85	480.02	470.44
14-09-1989	4160										
15-09-1989	4159	49									
16-09-1989	4379										
17-09-1989	4119	15									
18-09-1989	4223										

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
19-09-1989	3824										
20-09-1989	4209	1						441.89			
20-09-1989			515.28								
20-09-1989					477.05	500.74			461.86	479.89	470.40
21-09-1989	4002										
22-09-1989	4404										
23-09-1989	4093	1									
24-09-1989	4185	1									
25-09-1989	4220										
26-09-1989	4186	38									
27-09-1989	4300	0						442.13			
27-09-1989			515.51								
27-09-1989					477.10	500.84			461.89	480.03	470.36
28-09-1989	3893										
29-09-1989	4055										
30-09-1989	3887										
01-10-1989	3959										
02-10-1989	4073										
03-10-1989	3926	34									
04-10-1989	4177							447.47			
04-10-1989			515.59								
04-10-1989					477.11	500.93			461.97	481.37	470.51
05-10-1989	3233							447.14			
06-10-1989	3779	7						447.28			
07-10-1989	4160	3									
08-10-1989	4116										
09-10-1989	4022	3									
10-10-1989	3952							447.75			
11-10-1989	3855	50						447.88			
11-10-1989			515.46								
11-10-1989					476.79	500.65			462.05	480.61	470.37
12-10-1989	4247	1						447.67			
13-10-1989	4012							448.22			
14-10-1989	3669										
15-10-1989	3835										
16-10-1989	3931	0						447.18			
16-10-1989			515.79								
16-10-1989					477.10	500.77			462.57	480.77	470.76
17-10-1989	3843	10						447.77			
18-10-1989	3841	1						447.79			
18-10-1989			515.61								
18-10-1989					477.04	500.70			462.47	480.55	470.66
19-10-1989	3851							447.06			
20-10-1989	3889	0						447.61			
21-10-1989	4360	23									
22-10-1989	4589										
23-10-1989	4077							448.40			
24-10-1989	4163							448.98			
25-10-1989	4235							448.42			
25-10-1989			515.58								

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
25-10-1989					476.97	499.91			461.93	480.49	470.28
26-10-1989	4076							447.37			
27-10-1989	4189							446.05			
28-10-1989	4031										
29-10-1989	3930										
30-10-1989	3952							446.88			
31-10-1989	3972							447.47			
01-11-1989	4033	18						447.22			
01-11-1989			515.32								
01-11-1989					477.08	499.06			461.65	480.40	470.05
02-11-1989	4214							446.51			
03-11-1989	3513	9						447.68			
04-11-1989	4022										
05-11-1989	3735										
06-11-1989	3863	9						447.57			
07-11-1989	3832							447.77			
08-11-1989	3908							445.50			
08-11-1989			515.58								
08-11-1989					476.99	498.22			461.54	480.30	469.87
09-11-1989	3776	13						444.90			
10-11-1989	3889	9						444.60			
11-11-1989	3780										
12-11-1989	3805	6									
13-11-1989	3787										
14-11-1989	3716	8						445.67			
15-11-1989	3739	5						445.77			
15-11-1989			515.71								
15-11-1989					476.91	497.76			461.62	480.42	469.83
16-11-1989	4024	1						446.06			
17-11-1989	3912	13						446.69			
18-11-1989	4212	7									
19-11-1989	4117	1									
20-11-1989	4194	6						447.57			
21-11-1989	3855	25						447.22			
22-11-1989	4240	5									
22-11-1989			515.99								
22-11-1989					477.26	498.35			461.78	480.69	469.93
23-11-1989	3422	7									
24-11-1989	3632	0						447.02			
25-11-1989	3495	0									
26-11-1989	2965	7									
27-11-1989	2120	1						446.22			
27-11-1989											
27-11-1989								454.18			
27-11-1989								455.47			
27-11-1989			515.56								
27-11-1989					477.10	497.83			461.60	480.27	469.66
28-11-1989	590	17						465.83			
28-11-1989								469.84			
28-11-1989			515.49								

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
28-11-1989					477.00	497.71			467.05	480.92	471.72
28-11-1989					477.07	497.86			468.86	481.17	472.80
29-11-1989	566							477.84			
29-11-1989								479.72			
29-11-1989			515.64								
29-11-1989					477.21	497.89			475.42	481.49	475.28
29-11-1989					477.20	497.84			477.29	482.28	475.97
30-11-1989	457	0						483.87			
30-11-1989								484.90			
30-11-1989			515.79								
30-11-1989					477.12	497.90			482.28	486.93	478.08
01-12-1989	1190	1						487.07			
01-12-1989								486.77			
01-12-1989			515.73								
01-12-1989					477.19	497.98			484.64	489.05	480.20
01-12-1989					477.18	497.95			484.73	489.26	480.71
02-12-1989	2681							486.41			
03-12-1989	2905	21									
04-12-1989	2974	0						486.94			
04-12-1989								486.87			
04-12-1989			515.61								
04-12-1989					477.41	498.10			485.66	490.09	484.78
05-12-1989	3058							487.00			
05-12-1989								487.19			
05-12-1989			515.71								
05-12-1989					477.32	498.02			486.04	490.79	485.37
05-12-1989					477.31	498.02			486.14	490.67	485.54
06-12-1989	3155							487.57			
06-12-1989			515.60								
06-12-1989					477.23	497.85			486.59	491.25	486.08
07-12-1989	3024	2						487.82			
08-12-1989	3313	0						488.33			
08-12-1989			515.64								
08-12-1989					477.23	497.69			487.46	492.09	487.48
09-12-1989	3384							487.73			
10-12-1989	3425							487.31			
11-12-1989	3518							486.32			
11-12-1989			515.65								
11-12-1989					477.34	497.82			486.83	490.66	488.14
12-12-1989	3475							486.39			
13-12-1989	3794	0						484.41			
13-12-1989			515.34								
13-12-1989					477.31	497.97			484.71	489.75	488.08
14-12-1989	3739							483.15			
15-12-1989	3465							481.92			
15-12-1989			515.33								
15-12-1989					477.21	498.19			482.09	487.02	486.96
16-12-1989	3957	1									
17-12-1989	3649	1									
18-12-1989	3591	0						479.42			

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	R4
18-12-1989			515.29								
18-12-1989					477.17	497.66			479.55	484.64	485.25
19-12-1989	3743							479.07			
20-12-1989	3903							478.55			
20-12-1989			515.27								
20-12-1989					477.06	497.49			478.70	483.48	484.52
21-12-1989	3635	1						478.13			
22-12-1989	3499							477.40			
22-12-1989					477.08	497.53			477.39	482.26	483.59
23-12-1989	3499										
24-12-1989	3495										
25-12-1989	3349										
26-12-1989	3347	5									
27-12-1989	3370	2						475.96			
27-12-1989					477.02	497.51			475.65	481.01	481.76
28-12-1989	3835	1									
28-12-1989											
29-12-1989	2994							475.51			
30-12-1989	2847							477.11			
31-12-1989	2792	7						478.77			
01-01-1990	2634	13						479.43			
02-01-1990	2994							479.31			
02-01-1990			515.34								
02-01-1990			515.34								
02-01-1990					476.89	497.51			478.30	482.98	482.64
03-01-1990	3287							476.84			
03-01-1990			515.44								
03-01-1990											
03-01-1990					476.80	497.62			476.63	481.23	482.33
04-01-1990	3641	2						475.75			
04-01-1990											
05-01-1990	3380						475.01	476.64			
05-01-1990			515.43								
05-01-1990					476.85	497.66			476.04	481.01	481.49
06-01-1990	3360	1									
06-01-1990											
07-01-1990	3315										
08-01-1990	3287	0					474.00	476.17			
08-01-1990			515.38								
08-01-1990					476.70	497.66			475.95	480.99	481.17
09-01-1990	3299							475.80			
09-01-1990											
10-01-1990	3383	22					474.01	475.52			
10-01-1990			515.32								
10-01-1990					476.65	497.41			475.48	480.74	481.03
11-01-1990	3713	1						475.20			
11-01-1990											
12-01-1990	3693	5					472.97	474.52			
12-01-1990			515.66								
12-01-1990					476.77	497.32			474.58	480.83	480.72

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	B6
13-01-1990	3294	1									
13-01-1990								476.25			
14-01-1990	3428	1									
15-01-1990	3613	0						476.46			
15-01-1990			515.69				472.29	476.15			
15-01-1990											
16-01-1990	3578	2			476.51	496.94			475.84	480.62	480.79
16-01-1990								472.43			
17-01-1990	3688										
17-01-1990			515.41				467.54	469.66			
17-01-1990											
18-01-1990	3829	1			476.55	496.84			471.07	480.81	479.40
18-01-1990								467.04			
19-01-1990	4025										
19-01-1990			515.39					465.74			
19-01-1990											
20-01-1990	3901				476.70	497.17			468.16	480.63	477.22
20-01-1990											
21-01-1990	3695	1									
22-01-1990	3548	1									
22-01-1990			515.35					463.76			
22-01-1990											
23-01-1990	3381	2			476.59	497.34			466.76	480.52	475.53
23-01-1990								463.60			
24-01-1990	3789	6									
24-01-1990			515.28				459.91	462.39			
24-01-1990											
25-01-1990	3675	5			476.51	497.40			465.75	480.48	474.27
25-01-1990								462.00			
26-01-1990	3628	19									
26-01-1990			515.39				458.87	461.14			
26-01-1990											
27-01-1990	4074	7			476.58	497.41			464.75	480.48	473.38
27-01-1990											
27-01-1990								459.94			
27-01-1990								459.66			
27-01-1990								459.53			
28-01-1990	3906										
29-01-1990	4449	2						457.67			
29-01-1990											
29-01-1990								448.51			
29-01-1990								447.66			
30-01-1990	4267	12						447.43			
31-01-1990	3777							446.68			
31-01-1990			515.79					451.39			
31-01-1990											
01-02-1990	4216	0			476.87	496.28			461.51	480.18	470.52
01-02-1990								449.56			
02-02-1990	4219										
03-02-1990	3958							448.50			

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	#4
04-02-1990	3731	3									
05-02-1990	3111	3						446.78			
06-02-1990	3608	3						447.36			
07-02-1990	3703							447.15			
07-02-1990					476.70	493.52			461.18	480.72	469.91
08-02-1990	3787							445.62			
08-02-1990											
09-02-1990	3350							451.99			
10-02-1990	3701	35									
11-02-1990	4215										
12-02-1990	3535							454.94			
13-02-1990	4069	1						458.29			
14-02-1990	3686	0						460.89			
14-02-1990			515.65								
14-02-1990					477.01	497.57			465.06	481.22	471.82
15-02-1990	3755	2						462.92			
15-02-1990											
16-02-1990	3660	5						463.85			
17-02-1990	3697	2									
18-02-1990	3522										
19-02-1990	3454	0						461.99			
20-02-1990	3323							460.57			
21-02-1990	3221						457.79	460.01			
21-02-1990			515.31								
21-02-1990					476.66	491.54			464.23	480.66	472.13
22-02-1990	2971	4						460.06			
22-02-1990											
23-02-1990	3258	5						461.17			
24-02-1990	3319	40									
25-02-1990	3372										
26-02-1990	3307							462.63			
27-02-1990	3440	2						463.19			
28-02-1990	3163	3					462.78	464.39			
28-02-1990			515.37								
28-02-1990					476.64	500.53			465.97	480.73	473.02
01-03-1990	3099	0						465.02			
01-03-1990											
02-03-1990	3131							465.36			
03-03-1990	3102	0									
04-03-1990	2965	2									
05-03-1990	3018	2						465.87			
06-03-1990	3387							466.13			
07-03-1990	3221						464.72	466.45			
07-03-1990			515.25								
07-03-1990					476.42	500.48			467.05	480.56	473.88
08-03-1990	2962							466.47			
08-03-1990											
09-03-1990	3256							462.17			
10-03-1990	3853										
11-03-1990	3683										

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
12-03-1990	3258							450.84			
13-03-1990	3298							447.84			
14-03-1990	3147	1					450.24	452.56			
14-03-1990			515.21								
14-03-1990					476.38	500.60			460.67	480.45	469.52
15-03-1990	3260	14						448.92			
15-03-1990											
16-03-1990	3379	1						444.92			
17-03-1990	3174										
18-03-1990	3278	5									
19-03-1990	3253							445.07			
20-03-1990	3390	5						445.22			
21-03-1990	3433	19					441.41	446.72			
21-03-1990			515.80								
21-03-1990					476.53	500.86			460.34	480.67	469.02
22-03-1990	3482							445.22			
22-03-1990											
23-03-1990	3517	2						445.86			
24-03-1990	3620										
25-03-1990	3502										
26-03-1990	3483							445.07			
27-03-1990	3422							445.07			
28-03-1990	3412	1					441.37	445.07			
28-03-1990			515.39								
28-03-1990					476.44	500.65			460.47	480.50	468.90
29-03-1990	3141							446.72			
29-03-1990											
30-03-1990	3171							446.72			
31-03-1990	3469	7									
01-04-1990	3301	8									
02-04-1990	3303	28						446.72			
03-04-1990	3441	2						446.72			
04-04-1990	3460	25					440.60	446.72			
04-04-1990			516.04								
04-04-1990					476.78	500.89			460.81	480.82	468.86
05-04-1990	3827							446.72			
05-04-1990											
06-04-1990	3795	0						446.72			
07-04-1990	3784	6									
08-04-1990	3753	0									
09-04-1990	3638							446.72			
10-04-1990	3507	2						445.07			
11-04-1990	3805	49					441.12	445.07			
11-04-1990			515.71								
11-04-1990					477.43	500.97			458.99	481.06	469.05
12-04-1990	4045	0						445.07			
12-04-1990											
13-04-1990	4046										
14-04-1990	4129										
15-04-1990	4050	0									

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
16-04-1990	4139	25						446.72			
17-04-1990	4047	13						446.72			
18-04-1990	4198	6					440.33	446.72			
18-04-1990			515.88								
18-04-1990					477.45	500.89			459.05	480.83	469.09
19-04-1990	4103							446.72			
19-04-1990											
20-04-1990	3758							446.72			
21-04-1990	3800	15									
22-04-1990	4451	14									
23-04-1990	4261							446.72			
24-04-1990	4253							446.72			
25-04-1990	4108						439.90	446.72			
25-04-1990			515.68								
25-04-1990					477.51	500.86			459.36	480.67	469.01
26-04-1990	4108							446.72			
26-04-1990											
27-04-1990	3969	3						446.72			
28-04-1990	3851										
29-04-1990	3793										
30-04-1990	3629							446.72			
01-05-1990	3627	4						446.72			
02-05-1990	3506	2					439.72	446.72			
02-05-1990			515.35								
02-05-1990					477.51	500.90			458.62	480.67	468.72
03-05-1990	3525							446.72			
03-05-1990											
04-05-1990	3599							446.72			
05-05-1990	3528	20									
06-05-1990	3763	3									
07-05-1990	3464							446.72			
08-05-1990	3474							446.72			
09-05-1990	3447						439.59	446.72			
09-05-1990			515.45								
09-05-1990					477.38	500.87			458.40	480.51	468.49
10-05-1990	3473							446.72			
10-05-1990											
11-05-1990	3438	20						446.72			
12-05-1990	3600										
13-05-1990	3620	3									
14-05-1990	3433	19						446.72			
15-05-1990	3795							446.72			
16-05-1990	3911	3					439.53	446.72			
16-05-1990			515.76								
16-05-1990					477.34	500.94			458.61	480.54	468.71
17-05-1990	3973							446.72			
17-05-1990											
18-05-1990	3644	17						446.72			
19-05-1990	3740	3									
20-05-1990	3714	0									
21-05-1990	3714										

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	#4
22-05-1990	3588	11		18				446.72			
23-05-1990	3805	. 11		17			439.58	446.72	-		
23-05-1990			515.61								
23-05-1990					477.38	500.93			458.77	480.47	468.73
24-05-1990	4138	19		18				446.72			
24-05-1990											
25-05-1990	3995			17				446.72			
26-05-1990	4139			20							
27-05-1990	4249			21							
28-05-1990	3981			21				446.72			
29-05-1990	3982	3		22				446.72			
30-05-1990	4145	37		24			439.65	446.72			
30-05-1990			515.43								
30-05-1990					477.67	501.09			459.04	480.74	468.89
31-05-1990	4060			11				448.09			
31-05-1990											
01-06-1990				59				451.83			
01-06-1990	3914							452.35			
01-06-1990								453.25			
02-06-1990	3318							456.21			
03-06-1990	2998							459.39			
04-06-1990				77			466.69	467.53			
04-06-1990	2534	10						467.92			
04-06-1990			515.26								
04-06-1990					477.53	496.63			466.93	480.85	471.70
05-06-1990				68				462.62			
05-06-1990	3724							462.19			
05-06-1990											
06-06-1990				68			458.28	460.76			
06-06-1990	3774							460.40			
06-06-1990			515.39								
06-06-1990					477.50	497.32			464.25	480.65	471.03
07-06-1990				67				459.58			
07-06-1990	3896							459.41			
07-06-1990											
08-06-1990	3814			66				458.10			
09-06-1990	3929			64							
10-06-1990	3994										
11-06-1990	3935	8		59				454.20			
12-06-1990				52				449.34			
12-06-1990	3757							448.95			
13-06-1990				46				448.70			
13-06-1990	3542						441.48	446.72			
13-06-1990			515.05								
13-06-1990					477.30	500.80			458.66	480.53	468.92
14-06-1990	3560			48				448.90			
14-06-1990											
15-06-1990	3615			53				449.37			
16-06-1990	3747										
17-06-1990	3432										

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
18-06-1990	3371			62				453.89			
19-06-1990	3362			62				454.36			
20-06-1990	3320	14		62			452.72	454.51			
20-06-1990			515.00								
20-06-1990					477.34	500.97			458.67	480.38	468.52
21-06-1990	3689	23		62				454.78			
21-06-1990											
22-06-1990	3827	10		63				456.18			
23-06-1990	4271			68							
24-06-1990	4607	4									
25-06-1990				71				462.49			
25-06-1990	4183							462.37			
26-06-1990	4064			72				463.51			
27-06-1990	4384			71			460.05	462.14			
27-06-1990			515.60								
27-06-1990					477.83	501.14			464.83	480.78	471.68
28-06-1990				71				461.12			
28-06-1990	4527							460.52			
28-06-1990											
29-06-1990	4297	0		70				461.16			
30-06-1990	5156	7		53							
01-07-1990	4585			50							
02-07-1990	4512			46							
03-07-1990				40			441.44	446.72			
03-07-1990							450.66	451.48			
03-07-1990	4815	0					451.64	452.67			
03-07-1990							453.86	454.68			
03-07-1990			515.21								
04-07-1990				55			458.92	459.63			
04-07-1990	2787	0					460.42	461.13			
04-07-1990			515.21								
04-07-1990					477.88	501.21			462.87	480.85	469.91
05-07-1990				66			464.98	465.84			
05-07-1990	2972						466.40	467.40			
05-07-1990							465.98	467.22			
05-07-1990			515.21								
05-07-1990											
06-07-1990				67			466.54	467.69			
06-07-1990	3314						466.68	468.03			
06-07-1990			515.20								
07-07-1990	3480			62			467.84	468.75			
08-07-1990	3606			62			467.69	468.57			
09-07-1990				68			469.26	470.03			
09-07-1990	3350	1					469.08	469.94			
09-07-1990			515.18								
10-07-1990				65			468.46	469.35			
10-07-1990	3813	0					467.79	468.84			
10-07-1990			515.19								
11-07-1990				63			465.47	467.28			
11-07-1990	3598						467.62	468.52			

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	B4
11-07-1990			515.19								
11-07-1990											
12-07-1990					477.82	501.08			469.03	481.14	470.48
12-07-1990	3612			61			466.16	467.98			
12-07-1990			515.19				465.77	467.61			
12-07-1990											
13-07-1990	3743			66							
13-07-1990			515.19				464.82	466.66			
14-07-1990	3838										
15-07-1990	3886										
16-07-1990	3809			66							
16-07-1990			515.18				463.83	465.42			
17-07-1990	3829			67							
17-07-1990			515.18				463.73	465.31			
18-07-1990	4032			67							
18-07-1990			515.18				462.98	464.62			
18-07-1990											
19-07-1990	3893			68	477.71	501.05			466.76	481.18	472.73
19-07-1990			515.18				463.90	465.57			
19-07-1990											
20-07-1990	3914	10									
20-07-1990			515.18	69			463.46	464.98			
21-07-1990	3786	1		70							
22-07-1990	3889			71							
23-07-1990	3883	20		71							
23-07-1990			515.20				462.84	464.72			
24-07-1990	3944	3		68							
24-07-1990			515.22				461.51	463.24			
25-07-1990	3945	1		68							
25-07-1990			515.23				460.97	462.81			
25-07-1990											
26-07-1990	3862	3		66	477.50	500.97			464.67	481.17	471.91
26-07-1990			515.23				459.35	461.29			
26-07-1990											
27-07-1990	3675	0		60							
27-07-1990			515.22				457.57	459.36			
28-07-1990	3889			58							
29-07-1990	3862			58							
30-07-1990	3791			39							
30-07-1990			515.21				451.81	454.52			
31-07-1990	3954	10		24							
31-07-1990			515.20				448.73	451.95			
01-08-1990	4142	22		23							
01-08-1990			515.25				445.23	448.83			
01-08-1990											
02-08-1990	3981			24	477.51	501.12			458.76	480.99	468.78
02-08-1990			515.65				443.27	446.72			
02-08-1990											
03-08-1990	3712			24			446.84	449.83			

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	R4
03-08-1990			515.70								
04-08-1990	3854										
05-08-1990	4161			234							
06-08-1990	4156			24							
07-08-1990	4008	2		25			444.49	448.23			
07-08-1990			515.39								
08-08-1990	4041	11		22			442.72	446.72			
08-08-1990			515.34								
08-08-1990					477.26	500.91			458.80	480.95	468.43
09-08-1990	4612			22			440.45	446.72			
09-08-1990			515.33								
09-08-1990											
10-08-1990	4815			27			440.45	446.72			
10-08-1990			515.31								
11-08-1990	4084	3									
12-08-1990	4030	3		36							
13-08-1990	3919			34			440.45	446.72			
13-08-1990			515.27								
14-08-1990	3743	7		36			445.29	448.70			
14-08-1990			515.25								
15-08-1990	3686			37			445.97	449.41			
15-08-1990			515.24								
15-08-1990					477.26	500.98			458.30	480.72	468.04
16-08-1990	3746			41			446.45	449.88			
16-08-1990			515.22	41							
16-08-1990											
17-08-1990	3775			41			446.58	449.98			
17-08-1990			515.21								
18-08-1990	3984										
19-08-1990	4029	6									
20-08-1990	3824			42			446.78	450.16			
20-08-1990			515.20								
21-08-1990	4114			42			446.80	449.96			
21-08-1990			515.19								
22-08-1990	4016			43			446.52	449.78			
22-08-1990			515.19								
22-08-1990					477.11	500.91			458.23	480.55	462.79
23-08-1990	4041			41			445.48	448.57			
23-08-1990			515.18								
23-08-1990											
24-08-1990	3917			42			444.68	447.66			
24-08-1990			515.18								
25-08-1990	4014										
26-08-1990	3842										
27-08-1990	3638			40			442.52	446.72			
27-08-1990			515.17								
28-08-1990	3491	17		42			443.34	446.72			
28-08-1990			515.16								
29-08-1990	3849			41			443.97	446.72			

DATE	MINE DISCHARGE (USgm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	H4
29-08-1990			515.19								
29-08-1990					477.21	500.97			458.16	481.43	460.13
30-08-1990	4218			41			444.09	446.72			
30-08-1990			515.19								
30-08-1990											
31-08-1990	4035			42							
31-08-1990			515.18				444.60	446.72			
01-09-1990	4133										
02-09-1990	4145	1									
03-09-1990	4154	5									
04-09-1990	3924			42							
04-09-1990			515.17				445.45	448.47			
05-09-1990	4048			41							
05-09-1990			515.17				445.26	448.20			
05-09-1990											
06-09-1990	4191			43	476.99	500.88			458.06	480.95	460.18
06-09-1990			515.17				445.94	448.46			
06-09-1990											
07-09-1990	4023	7		43							
07-09-1990			515.17				445.70	448.65			
08-09-1990	4224	0		42							
09-09-1990	4126			43							
10-09-1990	3962	1		43							
10-09-1990			515.17				444.46	447.39			
11-09-1990	3961			41							
11-09-1990			515.17				444.02	446.72			
12-09-1990	3912	0		40							
12-09-1990			515.16				443.40	446.72			
12-09-1990											
13-09-1990	3958	0		41	476.84	500.81			457.82	480.90	460.00
13-09-1990			515.16				443.37	446.72			
13-09-1990											
14-09-1990	4012			41							
14-09-1990			515.16				444.26	446.72			
15-09-1990	3762	11		40							
16-09-1990	4088										
17-09-1990	3935	1		40							
17-09-1990			515.17				443.32	446.72			
18-09-1990	3855			40							
18-09-1990			515.18				443.04	446.72			
19-09-1990	3893			39							
19-09-1990			515.17				442.56	446.72			
19-09-1990											
19-09-1990					476.92	500.83			457.50	480.68	459.95
20-09-1990	3890	26		39							
20-09-1990			515.17	38			442.19	446.72			
21-09-1990	3900			38							
21-09-1990			515.31				441.79	446.72			
22-09-1990	3681			37							

DATE	MINE DISCHARGE (Ut/gm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	R4
23-09-1990	4057	32		38							
24-09-1990	3958			38			441.95	446.72			
24-09-1990			515.50								
25-09-1990	3858						442.39	446.72			
25-09-1990			515.56								
26-09-1990	3715						447.71	449.15			
26-09-1990			515.51								
26-09-1990					476.78	500.75			457.49	480.56	459.88
26-09-1990											
27-09-1990	3993	1					444.67	447.51			
27-09-1990			515.44								
28-09-1990	3986						444.04	446.88			
28-09-1990			515.37								
29-09-1990	4182										
30-09-1990	4142	0									
01-10-1990				39							
01-10-1990	4102	5					442.42	446.72			
01-10-1990			515.28								
02-10-1990	3924	5					441.72	446.72			
02-10-1990				38							
02-10-1990			515.27								
03-10-1990	3900						441.27	446.72			
03-10-1990				38							
03-10-1990			515.27								
03-10-1990					476.80	500.83			457.07	480.55	459.86
03-10-1990											
04-10-1990	3783						441.28	446.72			
04-10-1990				38							
04-10-1990			515.26								
05-10-1990	4014	8					440.85	446.72			
05-10-1990				38							
05-10-1990			515.27								
06-10-1990	3963										
06-10-1990											
07-10-1990	3945										
07-10-1990											
08-10-1990	3846										
08-10-1990				37							
09-10-1990	3772	1					440.87	446.72			
09-10-1990				36							
09-10-1990			515.22								
10-10-1990	3565	6					441.18	446.72			
10-10-1990				38							
10-10-1990			515.22								
10-10-1990					476.65	499.27			456.73	480.39	459.73
10-10-1990											
11-10-1990	3675						439.90	446.72			
11-10-1990				38							
11-10-1990			515.23								

DATE	MINE DISCHARGE (US gpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	#4
12-10-1990	3705						439.72	446.72			
12-10-1990				36							
12-10-1990			515.22								
13-10-1990	3549	8									
13-10-1990											
14-10-1990	3563	3									
14-10-1990											
15-10-1990	3315	1					439.98	446.72			
15-10-1990				36							
15-10-1990			515.31								
16-10-1990	3765						441.73	446.72			
16-10-1990				37							
16-10-1990			515.33								
17-10-1990	3455						446.47	449.27			
17-10-1990				42							
17-10-1990			515.32								
17-10-1990					476.59	500.56			457.05	480.36	459.79
17-10-1990											
18-10-1990	3458						444.81	448.28			
18-10-1990				41							
18-10-1990			515.29								
19-10-1990	3763	42					445.53	448.52			
19-10-1990				40							
19-10-1990			515.37								
20-10-1990	3759										
20-10-1990				40							
21-10-1990	3808										
22-10-1990	3743						446.63	449.80			
22-10-1990				41							
22-10-1990			515.72								
23-10-1990	3657	5					447.20	450.38			
23-10-1990				42							
23-10-1990			515.65								
24-10-1990	3697	41					447.69	450.75			
24-10-1990				42							
24-10-1990			515.59								
24-10-1990					476.64	500.78			457.12	480.51	459.78
24-10-1990											
25-10-1990	3912	0					448.30	451.47			
25-10-1990				42							
25-10-1990			515.74								
26-10-1990	3756	17					448.66	451.70			
26-10-1990				42							
26-10-1990			516.00								
27-10-1990	3980	7									
27-10-1990				41							
28-10-1990	4043										
29-10-1990	4093	65					450.30	453.10			
29-10-1990				43							

DATE	MINE DISCHARGE (US gpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	#4
29-10-1990			515.98								
30-10-1990	4614	4					452.29	454.80			
30-10-1990				46							
30-10-1990			516.44								
31-10-1990	4656						454.72	457.32			
31-10-1990				48							
31-10-1990			516.32								
31-10-1990					476.99	500.78			460.24	480.86	460.30
31-10-1990											
01-11-1990	4982						456.87	459.33			
01-11-1990				48							
01-11-1990			516.13								
02-11-1990	5144						458.09	460.69			
02-11-1990				50							
02-11-1990			515.99								
03-11-1990	4996	1									
03-11-1990				48							
04-11-1990	4882										
04-11-1990				54							
05-11-1990	5008						456.26	458.79			
05-11-1990				54							
05-11-1990			516.19								
05-11-1990			516.09								
05-11-1990					477.10	500.79			461.31	480.65	460.65
06-11-1990	4894	21					455.20	457.73			
06-11-1990				54							
06-11-1990			515.65								
07-11-1990	4857						453.80	456.12			
07-11-1990				51							
07-11-1990			515.70								
07-11-1990					477.08	500.81			459.01	480.52	460.04
07-11-1990											
08-11-1990	4694	1					452.01	454.79			
08-11-1990				48							
08-11-1990			515.75								
09-11-1990	4547						450.22	453.47			
09-11-1990				46							
09-11-1990			515.71								
10-11-1990	4537	1									
10-11-1990											
11-11-1990	4508	22									
11-11-1990				42							
12-11-1990	4411										
13-11-1990	4365	2					444.07	447.38			
13-11-1990				40							
14-11-1990	4317						443.28	446.72			
14-11-1990				40							
14-11-1990			515.73								
14-11-1990					477.00	500.79			456.97	480.28	459.95

DATE	MINE DISCHARGE (USgpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	B4
14-11-1990											
15-11-1990	3521										
15-11-1990				61			455.15	456.12			
15-11-1990			515.67								
16-11-1990	3185										
16-11-1990				55			457.80	459.80			
16-11-1990			515.61								
17-11-1990	4310	0									
18-11-1990	4266	60									
19-11-1990	4879	22									
19-11-1990				56			454.43	456.67			
19-11-1990			516.57								
20-11-1990	4961										
20-11-1990				58			456.41	458.57			
20-11-1990			516.48								
21-11-1990	5265	1									
21-11-1990				56			457.92	460.32			
21-11-1990			516.26								
21-11-1990					477.01	500.80			461.81	480.80	460.62
21-11-1990											
22-11-1990	5378	0									
22-11-1990				56			458.28	460.81			
22-11-1990			516.06								
23-11-1990	5213										
23-11-1990				57			458.59	461.20			
23-11-1990			515.93								
24-11-1990	4216	4									
25-11-1990	4743	2									
25-11-1990	4573										
25-11-1990							462.08	464.22			
26-11-1990							459.67	462.45			
26-11-1990				61							
26-11-1990			515.72								
27-11-1990	5170	2									
27-11-1990				55			456.72	459.52			
27-11-1990			515.68								
28-11-1990	5058										
28-11-1990				52			454.54	457.23			
28-11-1990			515.63								
28-11-1990					477.39	500.79			459.52	480.17	460.37
28-11-1990											
29-11-1990	4835	10									
29-11-1990				46			450.70	454.05			
29-11-1990			515.59								
30-11-1990	4776	0									
30-11-1990				40			446.25	449.91			
30-11-1990			515.61								
01-12-1990	4325										
01-12-1990				49			450.51	453.18			
02-12-1990	4414						446.29	449.52			

DATE	MINE DISCHARGE (Ml/gw)	TOTAL RAIN (mm)	RIVER LEVEL	#110 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW5	ETW1	ETW2	ETW3	R4
03-12-1990	4216						447.91	451.22			
03-12-1990				41							
03-12-1990			515.55								
04-12-1990	4384	52					443.14	446.72			
04-12-1990				39							
04-12-1990			515.48								
05-12-1990	4061	13					450.29	452.89			
05-12-1990				46							
05-12-1990			516.19								
05-12-1990					477.49	501.09			456.99	480.21	459.62
05-12-1990											
06-12-1990	4492						453.82	455.30			
06-12-1990				56							
06-12-1990			516.31								
07-12-1990	4784						454.09	456.65			
07-12-1990				50							
07-12-1990			516.11								
07-12-1990											
08-12-1990	4741	22									
08-12-1990				51							
09-12-1990	5189	10									
09-12-1990							455.47	457.92			
09-12-1990	5309	2					455.82	458.34			
09-12-1990				50							
10-12-1990				51							
10-12-1990			516.44								
11-12-1990	5498	1					457.15	460.34			
11-12-1990				50							
11-12-1990			516.08								
12-12-1990	5288						460.55	463.35			
12-12-1990				61							
12-12-1990			515.97								
12-12-1990					477.69	500.89			463.80	479.83	460.85
13-12-1990	5200	2					460.91	463.43			
13-12-1990				60							
13-12-1990			515.82								
14-12-1990	4850						461.69	464.54			
14-12-1990				76							
14-12-1990			515.73								
14-12-1990											
15-12-1990	4772	2									
15-12-1990				74							
16-12-1990	4660	46									
16-12-1990							461.00	463.54			
16-12-1990	4983	3					460.35	462.87			
16-12-1990				74							
17-12-1990				69							
17-12-1990			516.06								
18-12-1990	4955	4					460.28	462.68			

DATE	MINE DISCHARGE (US gpm)	TOTAL RAIN (mm)	RIVER LEVEL	#110 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	B4
18-12-1990				66							
18-12-1990			515.99								
19-12-1990	5069	2					460.85	463.26			
19-12-1990				66							
19-12-1990			515.92								
19-12-1990					477.87	501.00					
20-12-1990	5101								463.55	479.75	460.78
20-12-1990							460.16	462.43			
20-12-1990				67							
20-12-1990			515.87								
21-12-1990	5101	1					459.31	461.70			
21-12-1990				65							
21-12-1990			515.73								
22-12-1990	5047	12									
23-12-1990	4751	1									
23-12-1990				65							
24-12-1990	4620	8					457.21	459.40			
24-12-1990				60							
24-12-1990			515.76								
25-12-1990	4808	0									
26-12-1990	4508	1									
26-12-1990				54							
27-12-1990	4306						457.91	458.86			
27-12-1990				53							
27-12-1990			515.65								
27-12-1990					477.53	500.69			459.66	479.31	460.05
28-12-1990	4762						452.27	455.08			
28-12-1990				43							
29-12-1990	4762	3					447.32	450.22			
29-12-1990				38							
30-12-1990	4150	5					450.02	452.40			
30-12-1990				41							
31-12-1990	4211	6					447.18	449.78			
31-12-1990				48							
01-01-1991	3987			48							
02-01-1991	3844	1	515.52	44	477.71	500.91	446.21	449.21	456.61	479.30	459.36
03-01-1991	4083		515.48				444.68	447.57			
04-01-1991	4146		515.44	38			444.12	446.72			
05-01-1991	4044	1									
06-01-1991	3902	2									
07-01-1991	3515	0	515.37	34			440.98	446.72			
08-01-1991	3500		515.30	33			442.20	446.72			
09-01-1991	3446	3	515.37	23	477.55	500.79	445.68	446.72	456.08	479.29	459.11
10-01-1991	3068	8	515.35	25			449.60	450.84			
11-01-1991	3794		515.35	26			440.77	446.72			
12-01-1991	1982	11					457.12	457.36			
13-01-1991	2242	1					462.25	462.57			
14-01-1991	4138		515.35	39			454.00	455.65			
15-01-1991	3424	3		39			450.22	451.21			
16-01-1991	2860	15	515.30	42	477.57	500.79	453.81	454.63	456.64	479.31	459.17

DATE	MINE DISCHARGE (US gpm)	TOTAL RAIN (mm)	RIVER LEVEL	#118 (psi)	BOREHOLE WATER LEVELS						
					DW1	DW2	DW3	ETW1	ETW2	ETW3	#4
17-01-1991	2927	22	515.50	54			455.00	455.99			
18-01-1991	3338	1	515.88	47			454.18	455.12			
19-01-1991	2995	5		47							
20-01-1991	3046	0									
21-01-1991	2946		515.78	50			457.21	458.10			
22-01-1991	3870		515.82	41			448.37	450.58			
23-01-1991	3816	1	515.63	32	477.69	500.64	442.90	446.72	456.42	479.14	459.08
24-01-1991	3514	2	515.51	33			444.77				
25-01-1991	3423		515.44				445.25				
26-01-1991	3650						441.73				
27-01-1991	3433	1									
28-01-1991	3379	4	515.32				441.36				
29-01-1991	3419		515.31				441.38				
30-01-1991	3425	2	515.29		477.74	500.49	440.86		455.92	479.34	458.94
31-01-1991	3257	24	515.43				440.63				
01-02-1991	3478	1	515.53	34			441.10				
02-02-1991	3394										
03-02-1991	3421										
04-02-1991	3314		515.50	35			442.75				
04-02-1991	3352	1	515.47	35			443.40				
06-02-1991	3279		515.44	38	477.62	500.47	445.42	446.72	455.83	479.31	458.65
07-02-1991	3446	3	515.42	34			443.23				
08-02-1991	3376		515.41	34			443.54				
09-02-1991	3279										
10-02-1991	3420										
11-02-1991	3321	2	515.39	33			442.14				
12-02-1991	3273		515.39	33			441.17				
13-02-1991	3180		515.36	34	477.66	500.60	442.82	446.72	455.30	479.46	458.63
14-02-1991	3032	30	515.32	36			444.50				
15-02-1991	3409	3	515.56	34			442.27	446.72			
16-02-1991	3132	2									
17-02-1991	3043	1									
18-02-1991	3118		515.70	36			441.81	446.72			
19-02-1991	3213	1	515.62	35			443.68	446.72			
20-02-1991	3146		515.56	32	477.90	500.72	443.16	446.72	455.50	479.28	456.27

APPENDIX 2

PUMPING TEST ANALYSES

FIGURE 1

CONSTANT DISCHARGE TEST: PUMP BORE DW3

FIGURE 2

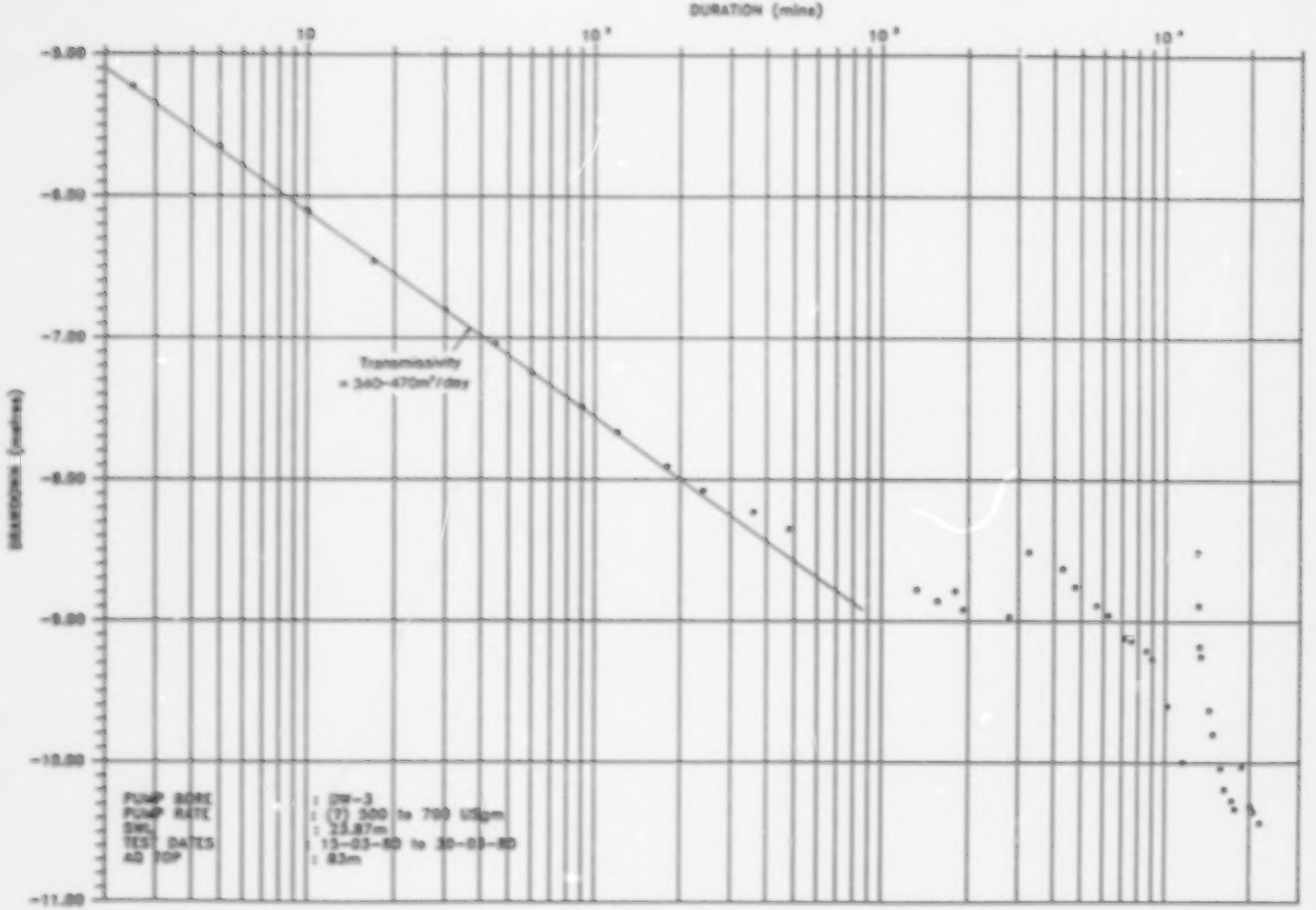
CONSTANT DISCHARGE TEST: SELECTED OBSERVATION BORES
SEMI-LOG PLOT GRCDSOBS.PLT

FIGURE 3

CONSTANT DISCHARGE TEST: SELECTED OBSERVATION BORES
LINEAR PLOT GRCDOBS.PLT

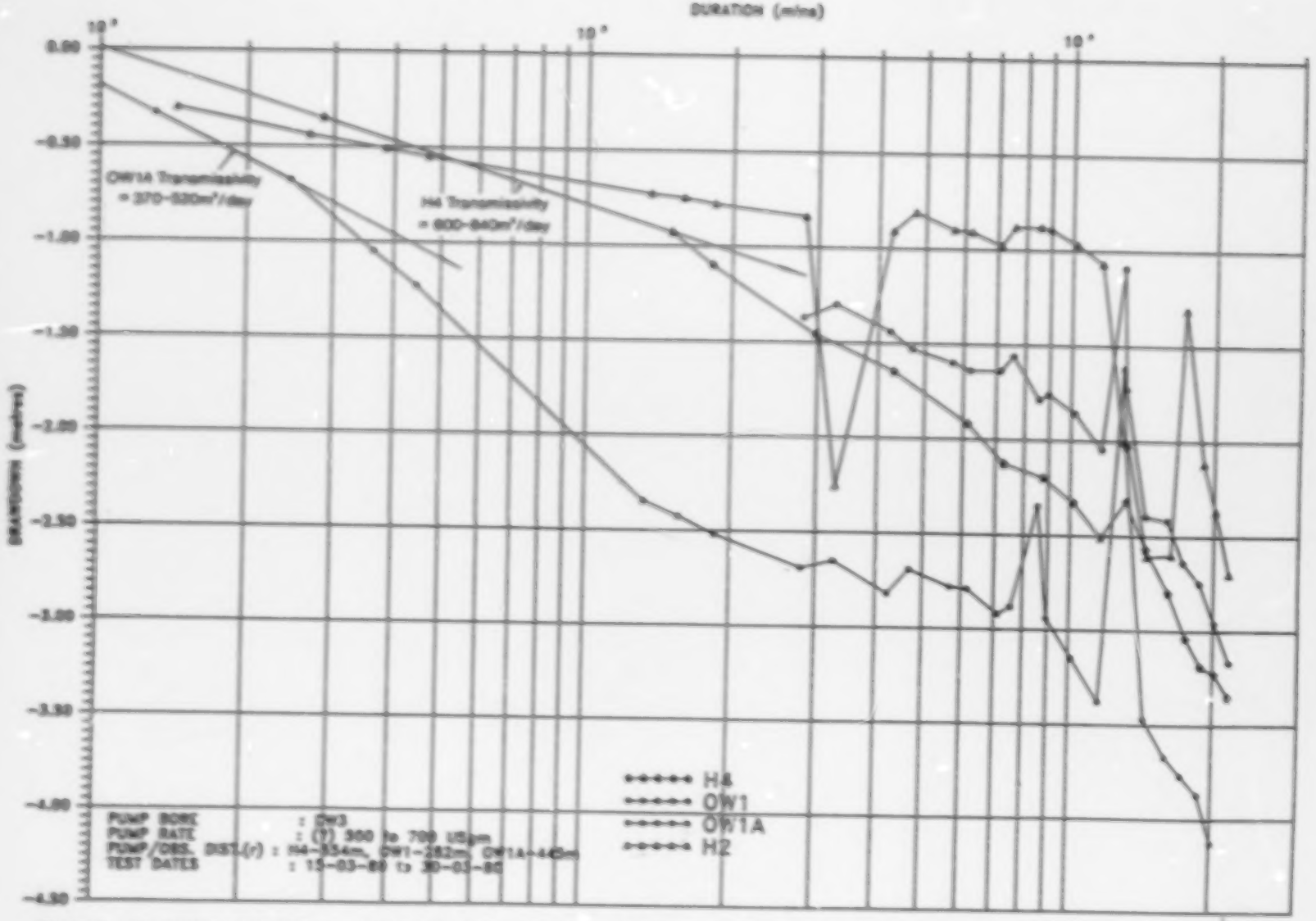
FIGURE 4

CONSTANT DISCHARGE TEST: MONITORING BORE DATA
GRCDMONT.PLT



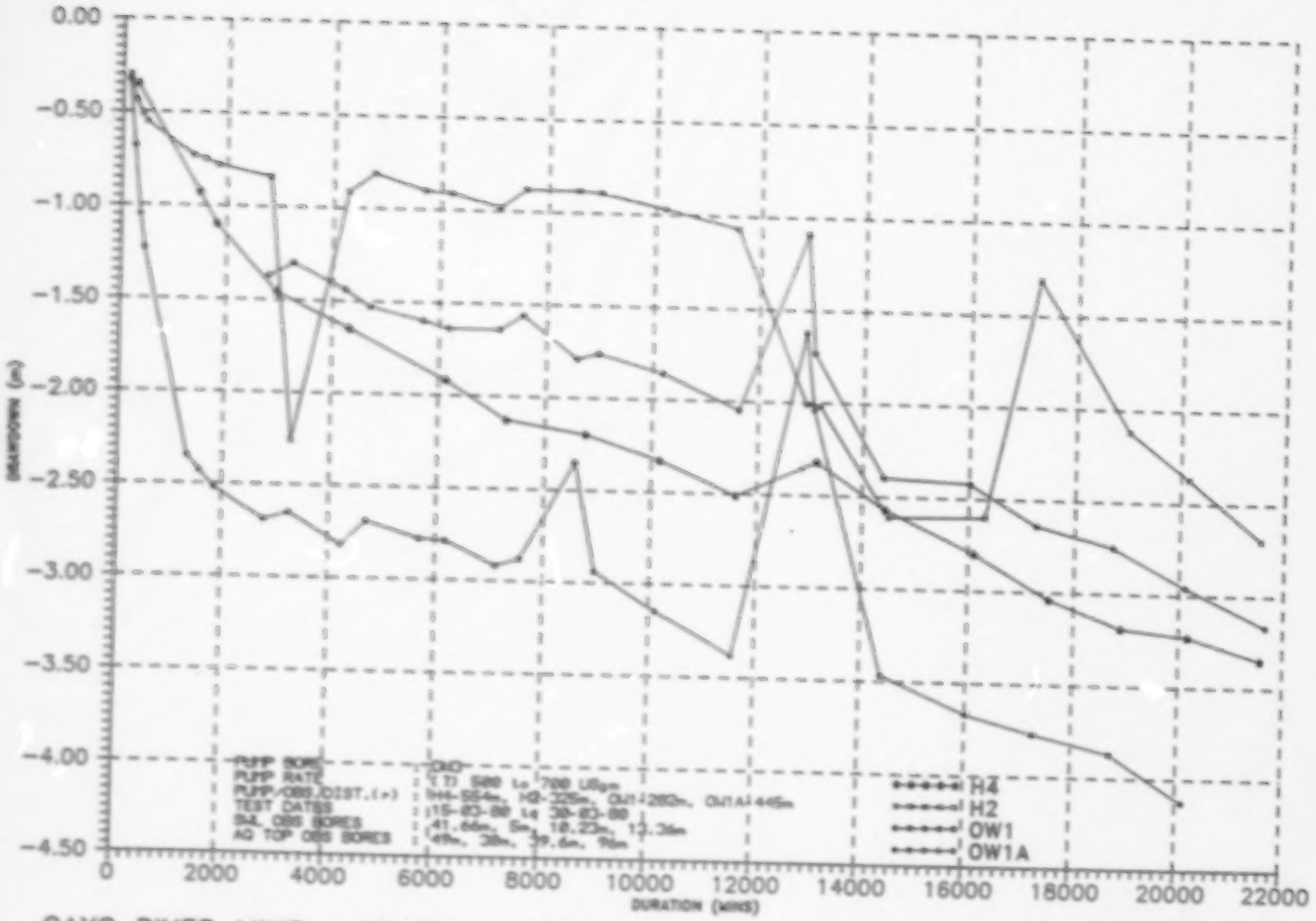
GAYS RIVER MINE : CONSTANT DISCHARGE TEST : PUMP BORE DW-3

PLAN NO.PC FILE GRCDOW3 APPENDIX 2 FIGURE 1



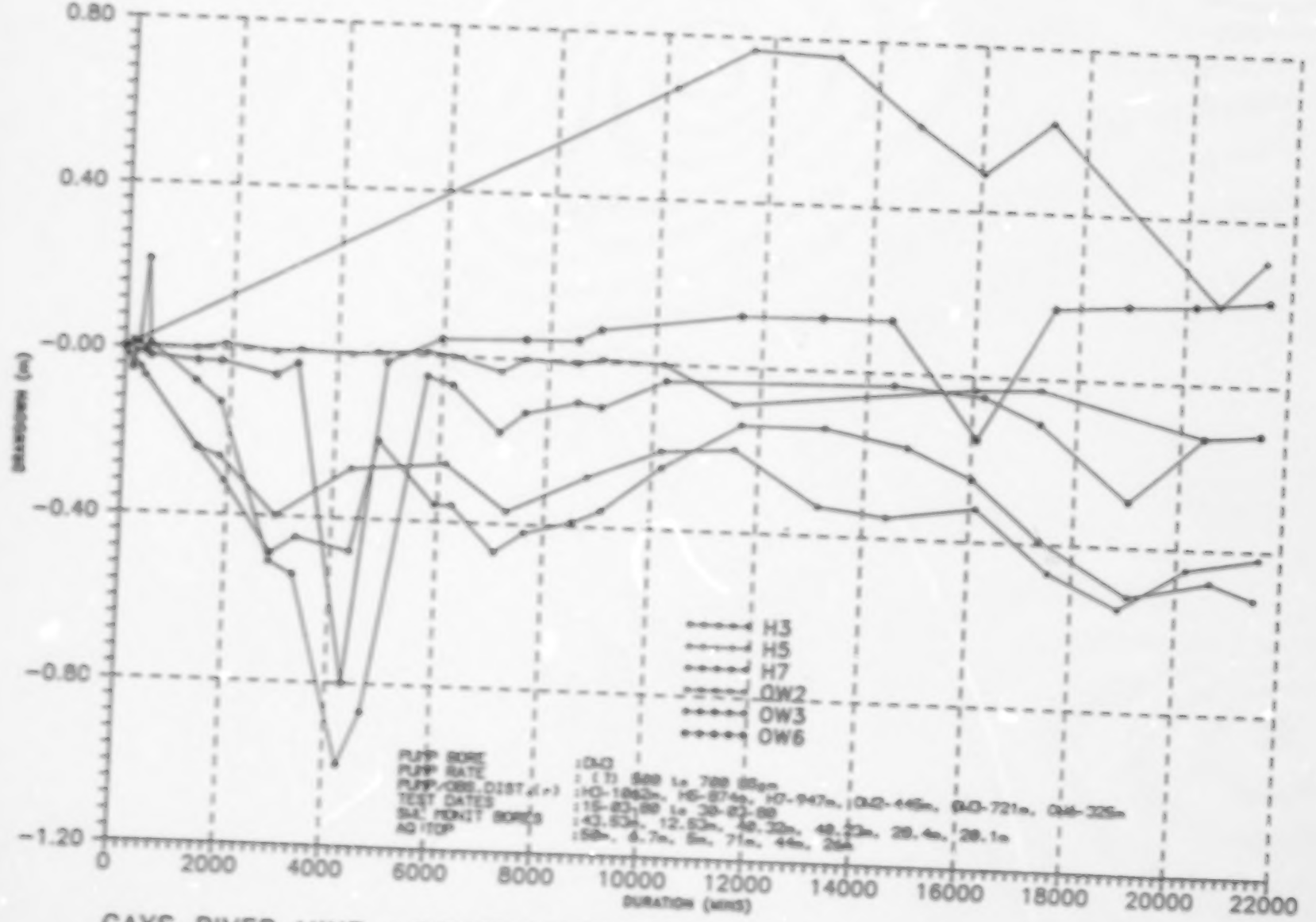
GAYS RIVER MINE : CONSTANT DISCHARGE TEST : SELECTED OBSERVATION BORES
SEMI- LOG PLOT

PLAN NO.PC FILE GRCDSOBS APPENDIX 2 FIGURE 2



GAYS RIVER MINE : CONSTANT DISCHARGE TEST : SELECTED OBSERVATION BORES

LINEAR PLOT



GAYS RIVER MINE : CONSTANT DISCHARGE TEST : MONITORING BORE DATA

PLAN NO.PC FILE GRCDMONT APPENDIX 2 FIGURE 4

APPENDIX 3

GROUNDWATER QUALITY

TABLE 1

GROUNDWATER ANALYTICAL SUMMARY

FIGURE 1

SCHOELLER DIAGRAM: SAMPLES TAKEN IN 1974
GRSCH74.PLT

FIGURE 2

SCHOELLER DIAGRAM: SAMPLES TAKEN IN 1980
GRSCH80.PLT

FIGURE 3

SCHOELLER DIAGRAM: SAMPLES TAKEN IN 1989
GRSCH89.PLT

FIGURE 4

TRILINEAR DIAGRAM: ALL SAMPLES (EXCL. WEIR MONITORING SAMPLES)
GRTRILIN.PLT

APPENDIX B

TABLE I

GROUNDWATER ANALYTICAL SUMMARY

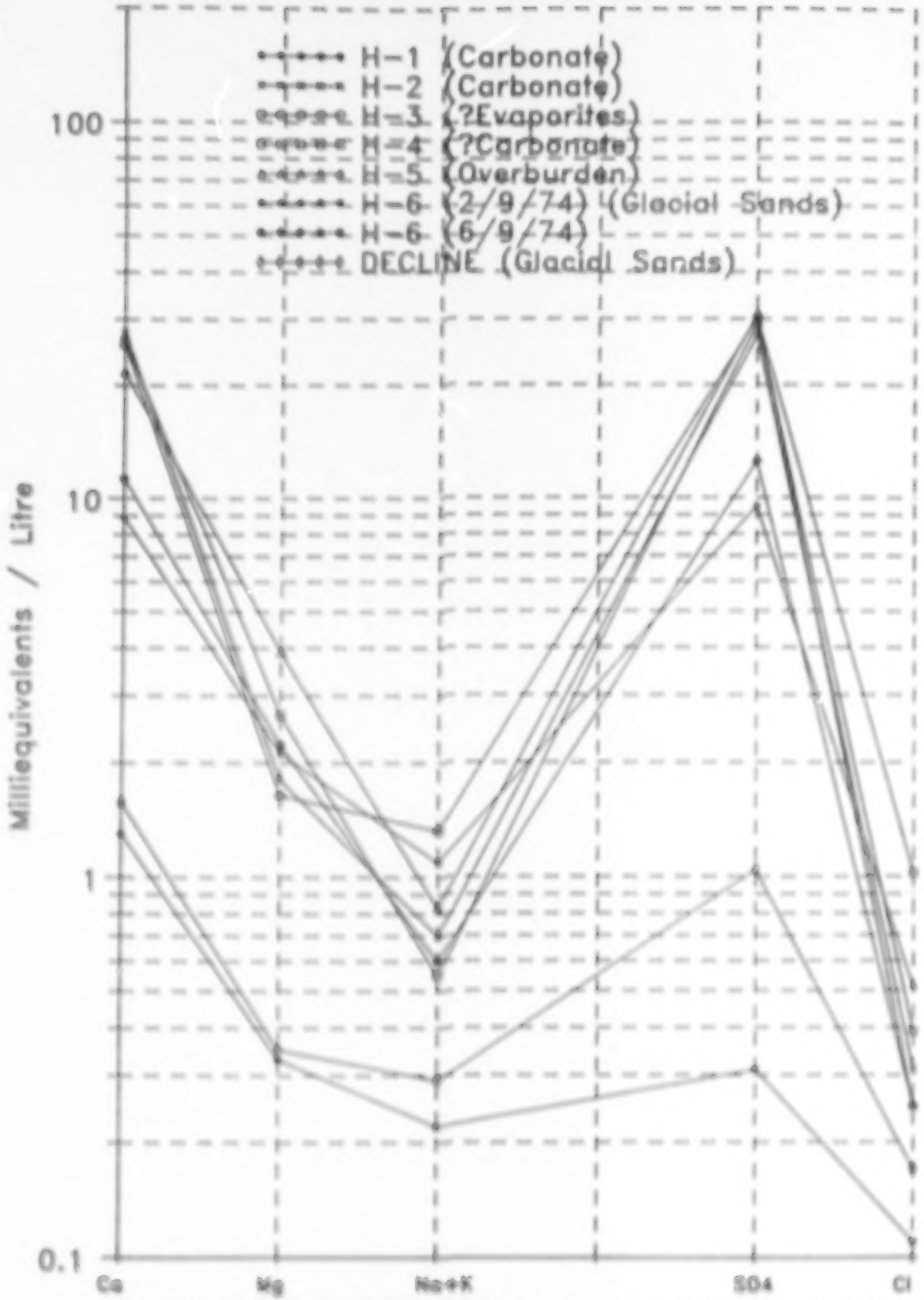
BASIC WATER ANALYSES

GAYS RIVER PROJECT

LOCATION	SAMPLE NO	SAMPLE DATE	AQUIFER NAME	pH	EC@25C umhos/cm	TSS	Na	Mg	Ca	K	Cl	SO4	HCO3	CO3	NO3
										mg/l					
#1060 DR	#1060 DR	23-01-1980		7.30	610		6.6	17.30	240.00	0.60	9.6	324.00	181.00		
#107 DR	#107 DR	23-01-1980		7.25	1525		28.0	14.60	576.00	1.20	26.0	1452.00	126.00		
#119 DR	#119 DR	23-01-1980		8.00	1150		5.7	7.20	569.00	33.00	12.0	1465.00	76.80		
DECLINE	DS-3	18-09-1974	GLACIAL SAD	7.50	567		6.0	4.20	31.40	1.20	6.0	50.00			
DW-3	DW-3	16-03-1980	EVAPORITES	7.60	1500		6.9	16.00	540.00	0.80	8.2	1325.00	160.00		
GAYS RIVER		17-01-1980		6.60	1120		3.6	1.50	21.00	0.40	6.8	44.00	11.00		
G-1	G1	18-07-1974	CARBONATE	7.50	1050		23.0	25.80	178.00	3.40	18.0	455.00			
G-2	G2	08-08-1974	CARBONATE	7.80	2140		15.0	21.90	955.00	1.90	11.0	1300.00			
G-3	G3	28-08-1974	EVAPORITES	7.70	2440		29.0	19.96	914.00	2.20	36.0	1450.00			
G-4	G4	22-08-1974	CARBONATE	7.70	2040		12.0	32.40	923.00	1.10	14.0	1480.00			
G-5	G5	25-09-1974	OVERBURDEN	6.30	1040		17.0	47.40	434.00	3.70	9.0	1480.00			
G-6	G6,1	02-09-1974	GLACIAL SAD	8.00	200		4.8	4.00	26.00	0.50	4.0	15.00			
G-6	G6,2	06-09-1974	"	"	7.90	1430		13.0	27.10	226.00	1.10	9.0	620.00		
MCI-GR-P1	P1DUR?	31-08-1980	OVERBURDEN	7.40	480		5.3	7.70	67.00	0.70	4.3	25.00			
MCI-GR-P2	P2DUR?	31-08-1980	OVERBURDEN	8.10	1055		19.0	17.00	130.00	1.70	7.6	350.00			
MCI-GR-P6	P6DUR?	2?-09-1980	OVERBURDEN	7.60	1630		18.6	17.90	233.00	1.40	11.0	590.00			
WEIR		19-04-1989		7.18	2000	40.0						1260.00	158.70		
WEIR		26-04-1989		7.33	1950	17.0						1150.00	171.90		
WEIR		03-05-1989		7.29	1900	39.0						1100.00	160.90		
WEIR		10-05-1989		7.26	1950	34.0						1070.00			
WEIR		17-05-1989		7.29	1700	42.0						1110.00	121.90		
WEIR		24-05-1989		7.40	1950	17.5						1100.00	143.10		
WEIR		31-05-1989		7.33	1950	43.0						1200.00	87.50		
WEIR		07-06-1989		7.44	1900	29.0						1200.00	97.50		
WEIR		14-06-1989		7.05	1950	12.0						1170.00	147.50		
WEIR		21-06-1989		7.67	1960	33.0						1140.00	134.10		
WEIR		28-06-1989		7.27	1300	18.0						1210.00	131.90		

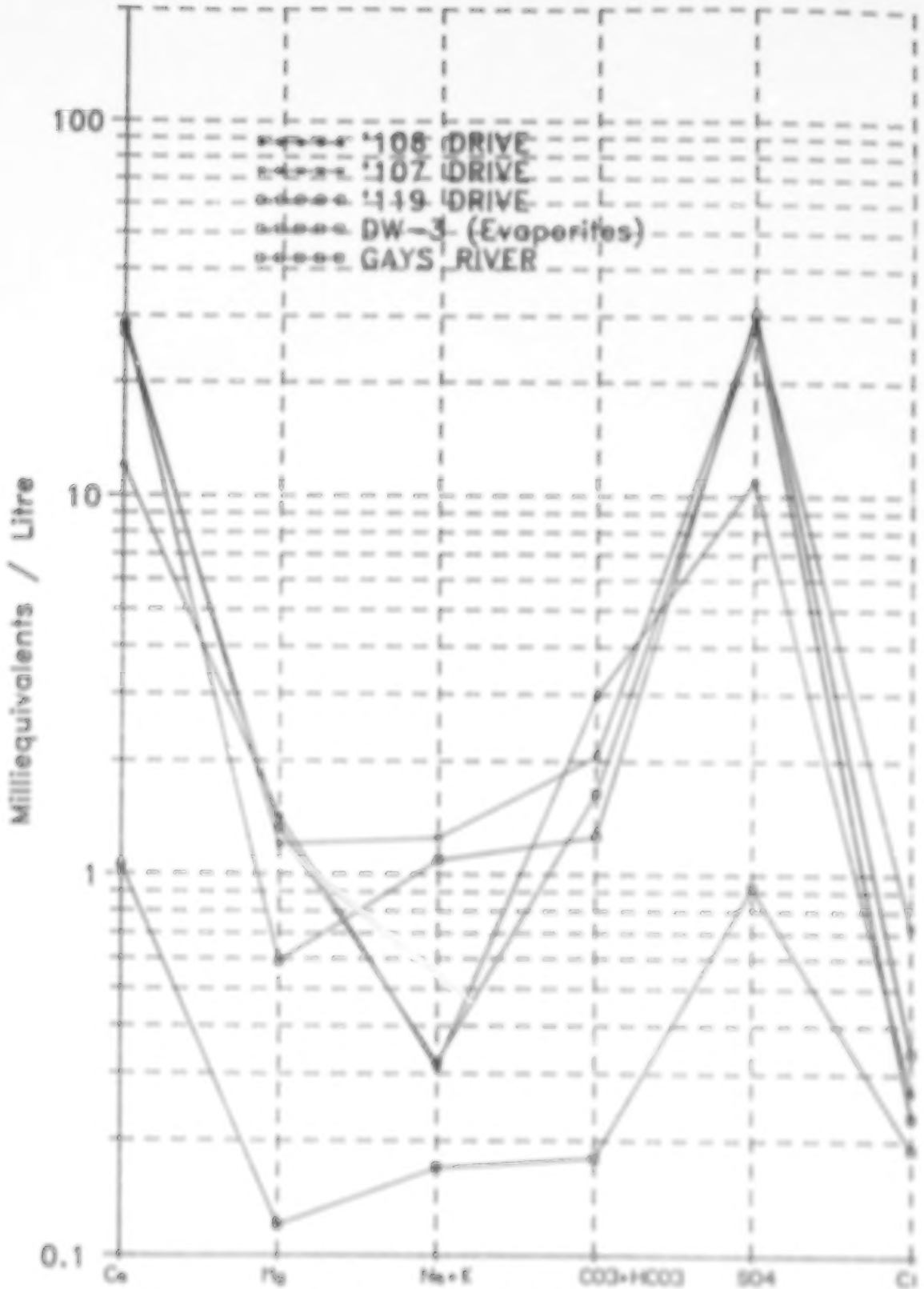
LOCATION	SAMPLE ID	SAMPLE DATE	AQUIFER NAME	pH	EC@25C umhos/cm	TDS	Na	Mg	Ca	K	Cl	SO4	HCO3	CO3	NO3
										mg/L					
WELL0		05-07-1989		7.33	1800	5.0						1220.00	121.90		
WELL0		12-07-1989		7.32	1650	64.0						1230.00	131.90		
WELL0		19-07-1989		7.33	1550	5.0						1210.00	112.90		
WELL0		26-07-1989		7.50	1200	15.0						1240.00	122.10		
WELL0		02-08-1989		7.00	1710	35.0						1230.00	138.50		
WELL0		09-08-1989		6.96	1750	74.0						1230.00	138.50		
WELL0		16-08-1989		6.61	1600	341.0						1220.00	156.30		
WELL0		23-08-1989		6.29	1250	5.0						1260.00	126.00		
WELL0		30-08-1989		7.38	1200	38.0						1290.00	114.80		
WELL0		06-09-1989		7.67	1350	29.0						1310.00	111.40		
WELL0		13-09-1989		6.71	1760	48.0						1280.00	110.70		
WELL0		20-09-1989		6.90	1800	49.0						1300.00	123.50		
WELL0		27-09-1989		6.91	3130	183.0						1180.00	129.50		
WELL0		04-10-1989		6.85	3120	168.0						1200.00	125.80		
WELL0		11-10-1989		7.58	2000	86.0						1210.00	85.30		
WELL0		18-10-1989		6.90	2000	122.0						1330.00	123.00		
WELL0		25-10-1989		6.73	2000	143.0						1350.00	114.70		
WELL0		01-11-1989		6.85	1900	146.0						1310.00	125.30		
WELL0		08-11-1989		6.50	3200	90.0						1290.00	130.90		
WELL0		15-11-1989		7.15	1700	75.0						1290.00	124.90		
WELL0		22-11-1989		7.21	1750	115.0						1290.00	123.60		
WELL0		29-11-1989		7.22	1500	46.0						969.00	87.80		
WELL0		06-12-1989		6.93	1900	214.0						1370.00	115.80		
WELL0		13-12-1989		6.91	1400	382.0						1300.00	117.30		
WELL0		22-12-1989		6.75	1400	2320.0						1260.00	123.40		
WELL0		27-12-1989		6.81	1550	76.0						1290.00			
WELL0		03-01-1990		6.84	1692	102.0						1280.00	128.00		
WELL0		10-01-1990		7.36	2240	52.0						1420.00	139.00		
WELL0		17-01-1990		7.42	2210	44.0						1290.00	165.00		
WELL0		24-01-1990		7.23	3510	28.0						1330.00	80.50		
WELL0		31-01-1990		7.37	4089	476.0						1320.00	112.00		
WELL0		07-02-1990		7.48	2401	276.0						1330.00	115.00		
WELL0		14-02-1990		7.90	2408	201.0						1310.00	73.10		
WELL0		21-02-1990		7.28	1900	231.0						1340.00	94.80		
WELL0		28-02-1990		7.90	1900	76.0						1330.00	80.70		
WELL0		07-03-1990		7.51	1350	84.0						1310.00	26.80		
WELL0		14-03-1990		7.36	1800	422.0						1350.00	141.00		
WELL0		21-03-1990		7.20	1300	4.0						1170.00	117.00		
WELL0		28-03-1990		7.87	1650	219.6						1300.00	85.80		
WELL0		04-04-1990		7.40	1700	247.0						1180.00	74.80		
WELL0		11-04-1990		7.14	2000	526.0						1130.00	92.10		
WELL0		18-04-1990		6.47	1300	208.0						1180.00	92.00		
WELL0		25-04-1990		6.84	1350	69.0						1170.00	98.00		
WELL0		02-05-1990		6.36	2200	143.0						1120.00	84.00		
WELL0		30-05-1990		7.39	1850	176.0						1140.00	88.80		
WELL0		06-06-1990		7.70	3100	40.0						1210.00	84.60		
WELL0		13-06-1990		7.50	3000	770.0						1060.00	89.70		
WELL0		20-06-1990		7.80	3020	157.0						1060.00	84.50		
WELL0		27-06-1990		7.80	2850	107.0						1140.00	92.40		
WELL0		04-07-1990		7.60	2930	35.0						1190.00	89.60		
WELL0		11-07-1990		7.70	3000	211.0						1180.00	95.50		

LOCATION	SAMPLE NO	SAMPLE DATE	AQUIFER NAME	pH	EC@25C uMhos/cm	TDS	Na	Mg	Ca	K	Cl	SO4	HCO3	CO3	NO3
										mg/L					
				--		---	--	--	--	--	--	---	----	---	---
WELL		18-07-1990		7.70	3300	555.0						1230.00	99.50		
WELL		25-07-1990		7.60	3060	158.0						1210.00	92.60		
WELL		01-08-1990		7.70	3300	818.0						1240.00	91.50		
WELL		08-08-1990		7.60	3060	391.0						1330.00	91.60		
WELL		15-08-1990		7.70	3100	324.0						1200.00	95.50		
WELL		22-08-1990		7.70	3100	324.0						1210.00	98.50		
WELL		29-08-1990		7.60	3270	189.0						1240.00	94.60		
WELL		05-09-1990		7.40	3250	2160.0						1260.00	95.80		
WELL		12-09-1990		7.90	3210	296.0						1240.00	95.20		
WELL		19-09-1990		7.80	2560	1.0						1010.00	64.60		
WELL		26-09-1990		7.80	3340	175.0						1290.00	96.40		
WELL		03-10-1990		7.80	3210	434.0						1250.00	97.40		
WELL		10-10-1990		7.80	3140	384.0						1300.00	98.40		
WELL		17-10-1990		7.80	3210	411.0						1220.00	100.00		
WELL		24-10-1990		7.90	3440	118.0						1260.00	98.20		
WELL		31-10-1990		7.80	3180	652.0						1000.00			
WELL		07-11-1990		7.80	3270							1150.00			
WELL		14-11-1990		7.70	2890							1210.00			
WELL		28-11-1990		7.90	2910	274.0						1090.00			
WELL		05-12-1990		7.40	3110	1750.0						1100.00			
WELL		19-12-1990		7.70	2770	260.0						1040.00			
WELL		28-12-1990		7.60	2960	213.0						1140.00			
WELL		02-01-1991		7.70	2960	108.0						1140.00			



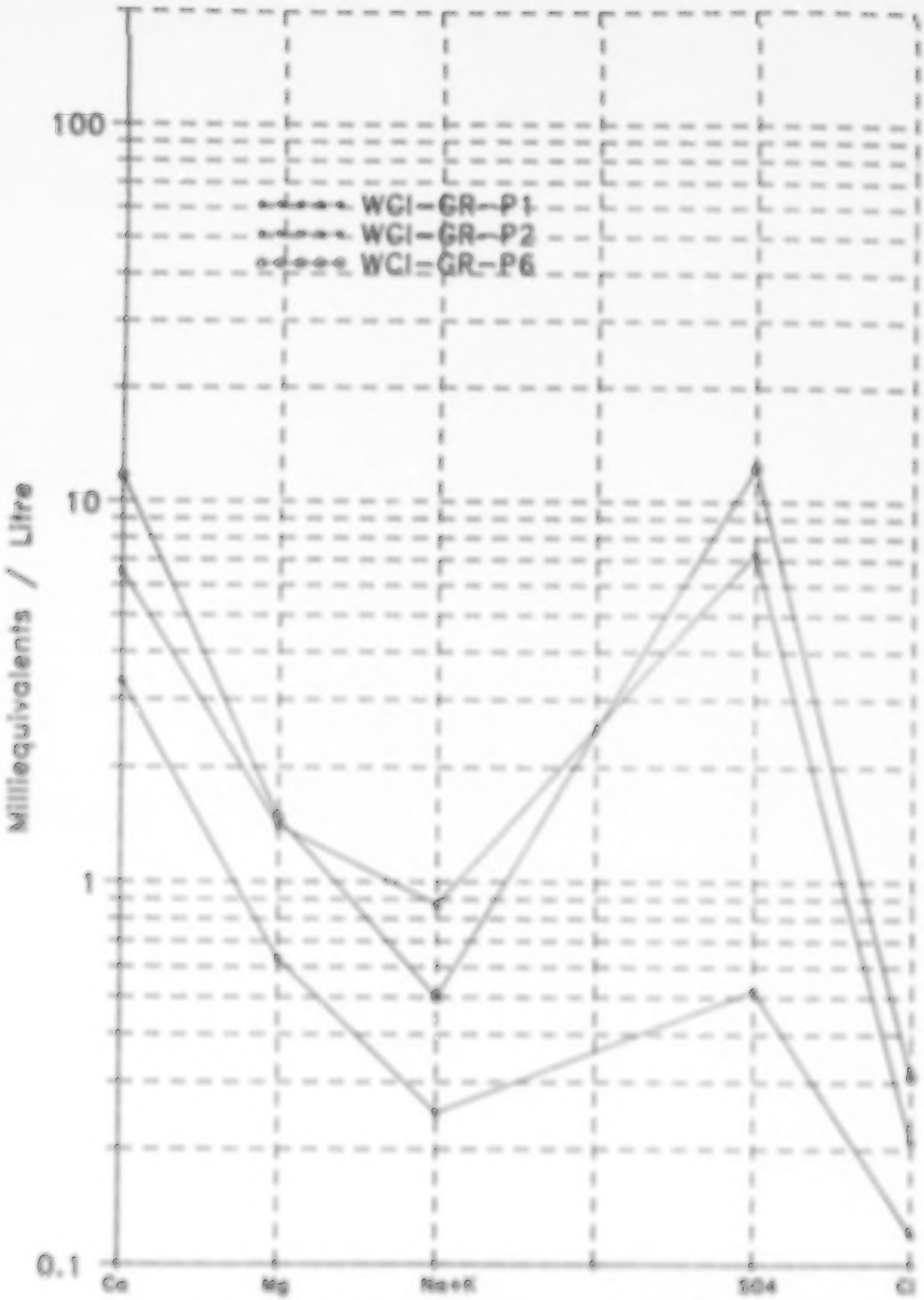
GAYS RIVER WATER QUALITY - SCHOELLER DIAGRAM
SAMPLES TAKEN IN 1974

PLAN NO. GRSCH74.PLT APPENDIX 3 FIGURE 1



GAYS RIVER WATER QUALITY - SCHOELLER DIAGRAM
SAMPLES TAKEN IN 1980

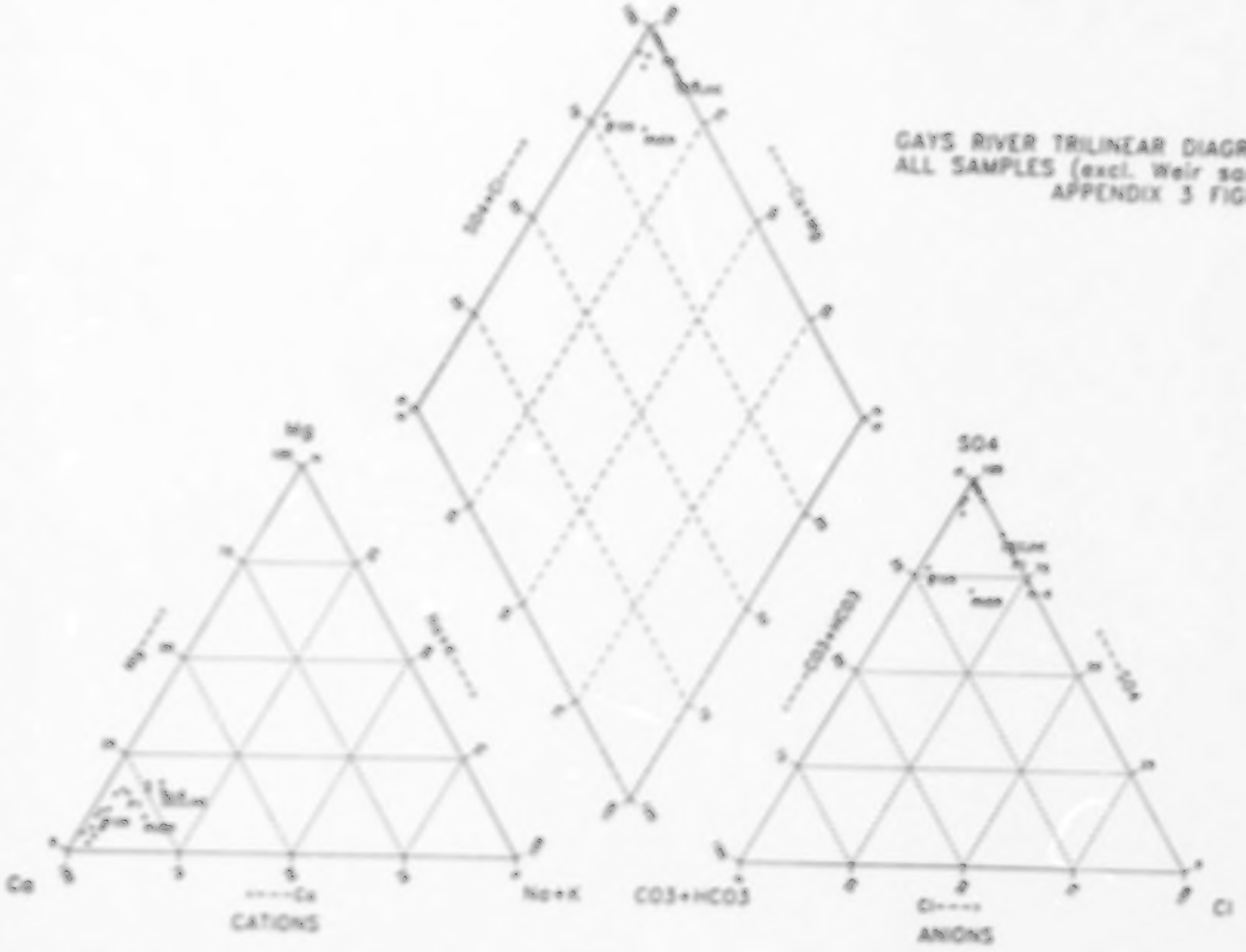
PLAN NO. GRSCH80.PLT APPENDIX 3 FIGURE 2



GAYS RIVER WATER QUALITY - SCHOELLER DIAGRAM
SAMPLES TAKEN IN 1989

PLAN NO. GRSCH89.PLT APPENDIX 3 FIGURE 3

GAYS RIVER TRILINEAR DIAGRAM
ALL SAMPLES (excl. Weir samples)
APPENDIX 3 FIGURE 4



MAPS
NOT
FILMED

CARTES
OMISES